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Abstract

How do people make decisions when simultaneously facing strategic and environmental uncertainty? Do entrepreneurs differ from others in this regards? This dissertation addresses these questions by investigating coordination behavior under dual uncertainty. Four economic experiments have been conducted comparing the behavior of entrepreneurs and non-entrepreneurs in settings that contain investment decisions into research and development and different aspects of competition and market entry decisions.

Keywords:

dual uncertainty, coordination behavior, entrepreneurial decision making, competition, market entry

Zusammenfassung

Wie beeinflusst das gleichzeitige Auftreten von strategischer und umfeldbedingter Unsicherheit das Entscheidungsverhalten? Unterscheiden sich Unternehmer in dieser Hinsicht von Anderen? Die vorliegende Dissertation behandelt diese Fragen und untersucht das Koordinationsverhalten bei dualer Unsicherheit. In vier ökonomischen Experimenten wird das Entscheidungsverhalten von Unternehmern und Nicht-Unternehmern vergleichend analysiert. Die betrachteten Entscheidungssituationen beinhalten Investitionsentscheidungen in Forschung und Entwicklung sowie verschiedene Aspekte des Wettbewerbs und von Markteintrittsentscheidungen.

Schlagwörter:

Duale Unsicherheit, Koordinationsverhalten, unternehmerisches Entscheidungsverhalten, Wettbewerb, Markteintritt

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1. Introduction

How do people make decisions when simultaneously facing environmental and strategic uncertainty? Do entrepreneurs differ from others in this regards?

In the following, I will give an introduction to these research questions that motivated my dissertation and point at the underlying interconnections between the different articles. The contributions of these studies to the literature are outlined and summarized.

1.1 Motivation

What we don't know often affects our decisions more than what we do know. The uncertainties we face might thereby stem from developments in the environment or from the interaction with others. Both types of uncertainty are fundamentally different in quality: environmental uncertainty is exogenous, the decision maker "plays against nature". Uncertainty stemming from the interaction with others is determined by the interdependence between the different actors and is marked by an endogenous, strategic character. In many decision situations both types of uncertainty appear simultaneously. We will refer to this as situations of dual uncertainty.

Entrepreneurs are particularly affected by dual uncertainty. Most of the decisions they make are characterized by the simultaneous existence of exogenous and strategic uncertainty. For example, when deciding whether or not to exploit an opportunity or enter an emerging market, entrepreneurs are confronted with uncertainty about the development of this market and the future demand. Simultaneously, they face strategic uncertainty with respect to the entry decisions of their competitors. Other examples are investment decisions into research and development where spillovers might allow to free-ride on the investments of others, pricing decisions, or the choice of technological standards. Even the decision to terminate a business might be subject to dual uncertainty. A theory of entrepreneurship thus needs to deal with two questions:

(1) How does dual uncertainty affect decision making?

(2) Do entrepreneurs differ from others in dealing with dual uncertainty?

This dissertation addresses these questions by investigating coordination behavior under dual uncertainty and by examining whether entrepreneurs differ from others in dealing with strategic and exogenous uncertainty. Economic experiments have been conducted with both, entrepreneurs and non-entrepreneurs. Their decision behavior is studied in scenarios that consider investment decisions into research and development (Article 1) and different aspects of market entry decisions and competition (Article 2 and 4). The forth study (Article 3) analyses effects of demand uncertainty and strength of competition on people's willingness to enter skill-based competition. These two aspects are at the heart of entrepreneurial entry decisions but also apply to a broader range of competitive situations.

1.1.1 Decision making under dual uncertainty

As a result of the fundamental differences between exogenous and strategic uncertainty, decision making under these two types of uncertainty has largely been approached in separate research streams. Decision making under environmental uncertainty has been studied in behavioral decision making while strategic uncertainty has been studied in behavioral game theory (Heukelom 2007). As a consequence, the number of studies dealing with behavior under dual uncertainty is limited. The results of these studies show that implications for decision making under dual uncertainty cannot readily be drawn based on the literature dealing with either strategic decision making or individual decisions under uncertainty (e.g., Dickinson 1998, Wit and Wilke 1998, Cabrales et al. 2007, Gong et al. 2009, Levati et al. 2009, Gangadharan and Nemes 2009, Brandts and Yao 2010, Karelaia and Hogarth 2010). Instead, people might react very differently to exogenous uncertainty in a strategic context than in a non-strategic decision situation. Behavior is likely to also depend on the way exogenous uncertainty is involved in strategic decision making. This gives rise to investigating the effects of exogenous uncertainty in strategic situations where environmental uncertainty is ubiquitous. An example that shows how much exogenous uncertainty can change strategic decision behavior is given by Gong et al. (2009) who investigate group cooperation under uncertainty. While groups are generally found to be less cooperative than individuals, Gong et al. (2009) show that under exogenous uncertainty groups are more cooperative than individuals and have a greater chance of managing their risks efficiently. This example illustrates that better understanding the influence of exogenous uncertainty on interactive decision making might have broad implications for risk management in the societal but also in the economic domain. Given the importance of exogenous uncertainty for societal problems it might not come as a surprise that most of the studies that have dealt with dual uncertainty examine resource dilemmas and public goods games. These studies investigate the influence of exogenous uncertainty on the size of the resource or the provision point of the public good (Rutte et al. 1987, Suleiman and Rapoport 1988, Messick et al. 1988, Budesu et al. 1990, 1992, 1995a, 1995b, De Vries and Wilke 1992, 1995, Biel and Gärling 1995, Dickinson 1998, Wit and Wilke 1998, Rapoport and Au 2001, Levati et al. 2009, Gangadharan and Nemes 2009). Only very few studies have analyzed coordination behavior under dual-uncertainty (e.g., Cabrales et al. 2007, Heinemann et al. 2004). Inspired by the global games paradigm of Carlsson and van Damme (1993), Cabrales et al. (2007) examine a coordination game with noisy signals about the true payoffs. By iterated deletion of strictly dominated strategies this incomplete information game leads to a unique solution which, on average, coincides with the risk dominant equilibrium outcome of the underlying coordination game. They find small, but significant differences in behavior between complete and incomplete information games with the equilibrium of the incomplete information game describing the observed behavior well. Heinemann et al. (2004) find similar results. Other authors investigate exogenous uncertainty in market entry scenarios (Brandts and Yao 2010, Karelaia and Hogarth 2010). Brandts and Yao (2010) examine how ambiguous versus risky information about the market capacity effects entry behavior in a market entry game. They find that average entry is higher under ambiguous information than under risky information. Karelaia and Hogarth (2010) examine people's willingness to enter skill-based competition when being faced with noisy signals about their skills. Here, payoffs are exogenously uncertain because people do not know whether they are truly good enough to succeed in the competition or the signal they received is faulty. This should have asymmetric effects on the behavior of high- and low-skilled individuals: while noisy signals on average increase the success chances for low-skilled people they decrease the success chances of high-skilled people. Their results show that low-skill individuals increase entry under additional uncertainty while high-skill individuals are not much affected by the additional uncertainty. While the behavior of low-ranked individuals is in line with predictions and to a large degree explained by rationality, no final conclusion could be drawn for the entry behavior of high-ranked individuals. The results of Karelaia and Hogarth (2010) emphasize the need for further research on this topic.

Article 1 ("Coordination under dual uncertainty: Comparing mixed strategy equilibria, risk dominance and a decision heuristic") contributes to this literature by investigating in how far established solution concepts from game theory can account for coordination under dual uncertainty. We experimentally test decision behavior in a two-player coordination game with asymmetric, risky payoffs and compare the explanatory power of mixed strategy equilibria, risk dominance, and a plausible decision heuristic. To explore the generalizability of our results we conduct the experiment with students and with high-tech entrepreneurs who are confronted with dual uncertainty in their profession. Allowing the entrepreneurs to connect to the decision scenario we frame the coordination game as a research and development scenario where players have to make an investment decision. The outcomes in this game depend on strategic uncertainty arising from two players' choices and exogenous uncertainty about the outcome of the investment. Coordination behavior in this game is compared to the predictions of mixed strategy equilibrium, the predictions of the risk dominance criterion, and a decision heuristic based on simple cost considerations and social projection. We find that the most satisfactory model in our comparison assumes linear relations to each player's cost and is consistent with the proposed heuristic model. Behavioral differences between students and entrepreneurs are surprisingly small and not statistically significant. Our findings suggest that under dual uncertainty simple behavioral models of behavior involving asymmetries and social projection might account better for behavior of actual decision makers than sophisticated game theoretic calculus. We propose a methodological approach to compare behavioral and game theoretic solution concepts.

Also Article 3 ("Demand uncertainty in skill-based competition: How what we cannot influence influences how we deal with what we can influence") contributes to the literature on decision making under dual uncertainty. Article 3 investigates the effect of exogenous demand uncertainty on peoples' willingness to enter skill-based competition. A market entry experiment has been conducted to test the effect of demand uncertainty for markets that differ in expected demand and strength of competition. The results show that under risky information about the demand, people overenter markets with a small expected demand and strong competition while they underenter markets with a high expected demand and weak competition. These findings are explained by people believing that competitors would shy away from entering highly competitive markets and assuming that they would overrun markets with weak competition. Overconfidence had a main effect on entry behavior but did not moderate reactions to market demand. These results are in line with previous research of on entry behavior in a deterministic market entry experiment were demand was given and payoffs did not depend on participants' skills Camerer et al. (2004). Camerer et al. (2004) found a reliable overentry in small markets and underentry in large markets tracing this finding back to people's beliefs. The article contained in this dissertation shows that the described effect of the size of demand is significantly more pronounced under demand uncertainty than under demand certainty. This leads to a s-shaped relation between the number of entrants and the expected demand in skill-based competition.

1.2 Entrepreneurship "through the lens of decision making"

Analyzing key questions in entrepreneurship as decision problems has been proposed by Schade and Burmeister-Lamp (2009). They argue that looking at entrepreneurial activity "through the lens of decision making" allows new insights and stimulates theory development in entrepreneurship research. Studying decision making requires detailed individual data which is often hard to access. Schade and Burmeister-Lamp (2009) suggest an experimental approach for gathering suitable data to study entrepreneurial decision making. Manipulating the variables of interest while keeping all else equal or controlled, experiments are able to provide detailed, meaningful individual information on decision making. Experiments thus complement surveys, field data, and theoretical contributions allowing focusing on individual differences between entrepreneurs and others. The experimental approach includes questionnaire experiments (e.g., Busenitz and Barney 1997, Burmeister and Schade 2007), hypothetical decision scenarios based on cases (e.g., Simon et al. 2000), conjoint experiments (e.g., Franke et al. 2006) and economic experiments that use monetary incentives (e.g., Sandri et al. 2010, Weitzel et al. 2010). As an understanding of the impact of economic incentives on decisions is crucial for understanding phenomena in entrepreneurship, the use of monetarily incentivized economic experiments for studying key questions in entrepreneurship is advocated by Schade and Burmeister-Lamp (2009). While most of the other forms of experiments mentioned are already established in entrepreneurship research, economic experiments have only recently experienced a growing interest among entrepreneurship researchers. Economic experiments investigating the decision behavior of actual entrepreneurs are particularly rare. One of the reasons for this is that entrepreneurs are “hard to get”. Winning entrepreneurs to participate in a laboratory experiment is more difficult than recruiting them for an online questionnaire experiment. Controlled laboratory experiments are particularly difficult in this regards as investigating strategic decisions often requires that a sufficient number of participants interact at the same time. Authors that have run economic experiments with actual entrepreneurs therefore have conducted experiments at large start-up conventions (Elston et al. 2006) or at Science Parks and Incubators (Sandri et al. 2010). Another issue that arises from conducting experiments with entrepreneurs is the question of monetary incentives. Economic experiments rely on monetary incentives to elicit people’s preferences. The majority of experimental economics studies are conducted with student subjects. Besides many other reasons, students make suitable subjects because incentivizing them is cost-efficient. Incentives given to high income individuals like entrepreneurs need to be scaled-up compared to students’ payoffs to provide the same relative incentive to both groups. Using students or people with entrepreneurial intensions as subjects is justified in many cases where the research question does not concern aspects that originate from entrepreneurial experience. If the aim is to better understand how entrepreneurs make decisions, replacing them by other groups of subjects fails to accomplish the task. Studying individual and interactive decision making of entrepreneurs as compared to different groups of non-entrepreneurs in incentivized economic experiments offers a wide range of opportunities for future research in entrepreneurship (Schade and Burmeister-Lamp 2009, Schade 2010).

In a number of not incentivized studies on individual decision making behavioral differences between entrepreneurs and non-entrepreneurs have been reported (e.g., Parlich and Bagby 1995, Busenitz and Barney 1997). Parlich and Bagby (1995) find entrepreneurs to be more biased and to categorize business scenarios more positively than non-entrepreneurs. Busenitz and Barney (1997) compare entrepreneurs to managers in large organizations and find that they are more susceptible to overestimate their own absolute skills and to the representativeness heuristic1. Questioning that entrepreneurs are generally more biased than other groups, Burmeister and Schade (2007) study the status quo bias with entrepreneurs as compared to bankers and students. They find that entrepreneurs are less status quo biased than bankers and not more than students, who due to their age and little experience should actually be less status quo biased than more experienced people. Their results show that entrepreneurs are not generally more biased than others and demonstrate that the extent to which entrepreneurs are affected by certain biases as compared to others depends on the domain and context under consideration.

Article 4 ("Does 'ego' make the entrepreneurs? Overconfidence, demand uncertainty and market entry") contributes to the literature on behavioral differences between entrepreneurs and others by shedding light on the connection between previous results on entrepreneurial overconfidence. Busenitz and Barney (1997) found entrepreneurs to be more susceptible to overestimating their absolute skills than non-entrepreneurs. Elston et al. (2006) found that entrepreneurs do not differ from others in overestimating their skills relative to competitors. When people overestimate their skills relative to others, this can be caused by them either overestimating their absolute skills or underestimating the skill level of their competitors, or by both together. Given this relationship, the results of Busenitz and Barney (1997) and Elston et al (2006) lead to the following inference: If entrepreneurs are more overconfident in their absolute skills than non-entrepreneurs (Busenitz and Barney 1997) but not more or less overconfident in their relative skills than non-entrepreneurs (Elston et al. 2006), they should, ceteris paribus, be less susceptible to underestimating their competitors, i.e., they should be less susceptible to the reference group neglect (Camerer and Lovallo 1999). Article 4 reports on a controlled laboratory experiment that investigates this relationship between absolute and relative overconfidence. The findings show no significant differences

[1] Applying the representativeness heuristic (Tversky and Kahneman 1974), people judge the probability of a hypothesis by considering how much the hypothesis resembles available data. For example if A is highly representative for B, the probability that A originates from B is judged to be high. If A is not similar to B, the probability that A originates from B is judged to be low. Although often useful, the representative heuristic can lead to severe errors and result in neglecting relevant base rates.

between entrepreneurs and non-entrepreneurs on either relative overconfidence or reference group neglect. These results suggest that it is not a pronounced level of relative overconfidence that distinguishes entrepreneurs from non-entrepreneurs. This finding adds to the growing evidence that excess market entry is rather caused by the nature of the decision environment and by the way people learn under uncertainty than by overconfidence as a fixed trait and by entrepreneurs exhibiting higher overconfidence levels per se (e.g., Moore et al. 2007, Karelaia and Hogarth 2010).

Also Article 2 ("Market entry decisions after gains and losses: gender matters, being an entrepreneur does not") contributes to the literature on behavioral differences between entrepreneurs and others. Our focus in this study is on differences between male and female entrepreneurs and on the question whether gender differences observed in context-dependent strategic decisions are smaller in the group of entrepreneurs than with non-entrepreneurs. Gender differences in context-dependent strategic decisions have been found by Schade et al. (2010). They relate their results to women's reluctance to enter competition and to compete with men (Niederle and Vesterlund 2011). As female entrepreneurs self-selected into a risky, highly competitive and mostly male dominated field, we expect behavioral differences between males and females to be smaller with entrepreneurs than with non-entrepreneurs. While our findings confirm gender differences in entry behavior, contrary to our expectations, this gender difference maintains with male and female entrepreneurs. It also maintains for women playing against other women. This surprising result raises questions for research on female entrepreneurship and for the participation of women in entrepreneurial activities outlined in Article 2.

1.3 Core results and contributions

The studies conducted within the scope of this dissertation lead to the following core results:

(1) *Simple models of behavior employing payoff asymmetries and social projection might account better for behavior under dual uncertainty than sophisticated game theoretic solution concepts.*

In Article 1, we study coordination behavior in a two-player investment game with asymmetric, stochastic payoffs and dual uncertainty. Under dual uncertainty, players are not only uncertain about their own payoffs but also about the payoffs of their counterparts. This causes a fundamental lack of knowledge about the preferences of counterpart players stemming from their differences in risk attitudes and other-regarding preferences (cf. Cabrales et al. 2007) or from reference point and context they refer to (cf. Kahneman and Tversky 1979, Schade et al. 2010). Comparing mixed strategy equilibria, risk dominance and a decision heuristic based on asymmetric cost and social projection, we find that the behavior is best describes by linear relations to each player's cost which are consistent with the proposed heuristic model. Predictions based on risk dominance, however, also predict behavior well. The proposed heuristic model and the risk dominance criterion lead to qualitatively similar results, i.e., predicting that the player with the lower costs invests and that the other tries to free ride. These findings are related to the results of Cabrales et al. (2007) who find that the equilibrium outcome in a game with incomplete information from noisy signals, on average, coincides with the risk dominant equilibrium of the underlying coordination game. Our findings are also related to the results on behavior in global games of Heinemann et al. (2004). Heinemann et al. (2004) argue that limited levels of reasoning about the other players' strategies and strategic uncertainty are the major forces that drive people to play the threshold-strategies observed in their experiment. Together with the results of Cabrales et al. (2007) and Heinemann (2004) our findings imply an underlying connection between mental short-cuts used in dual uncertainty games like focusing on payoff asymmetries and using social projection to by-pass uncertainty about the preferences of strategic counterparts and the incentive structure leading to risk dominance. Further research in this area might explore this connection in detail.

(2) *Demand uncertainty leads to pronounced overentry in skill-based competition when the strength of competition is very high and to pronounced underentry when the strength of competition is very weak.*

In Article 4, the focus is on exogenous demand uncertainty in skill-based competition. The study focuses on the interplay between the strength of competition and demand uncertainty. The results show that entry into skill-based competition is almost linearly increasing in expected demand when demand is given but s-shaped with asymmetric effects for extreme values of expected demand under demand uncertainty: under demand uncertainty people overenter markets with a low expected demand where competition is intense and they underenter markets with a high expected demand where competition is weak. The findings show that the pattern of over- and underentry is related to participants' beliefs about the entry behavior of their competitors but not moderated by either their level of overconfidence or by the true skill level. Some people belief that their competitors' shy away from entering markets with intense competition leading them to enter more. At the same time, people belief that their competitors overrun markets with weak competition leading them to underenter these markets. These results are in line with previous studies that documented overentry in markets with small certain capacities (Bolger et al. 2008, Pogrebna and Schade 2009) and with studies showing that reliable market over- and underentry can be explained by peoples' beliefs' about their competitors entry behavior (Camerer et al. 2004). The study contributes to this stream of literature by showing that demand uncertainty can amplify this phenomenon. This finding has implications for entrepreneurial start-up decisions in different types of markets. It implies that overentry might occur in industries that are subject to fierce competition and extremely risky in demand particularly because some entrepreneurs might assume their potential competitors to shy away from fierce competition. Correspondingly, the same logic might cause underentry in markets that are less competitive because demand is relatively high compared to the number of potential entrants. Similar implications can be drawn for other domains of skill-based competition where the expected demand is either extremely low or extremely high.

Article 1 and Article 3 both underline the role of limited reasoning about the choices of strategic counterparts. The fact that outcomes are often exogenously uncertain and that players have private information about their individual preferences towards risk, "fairness", and relevant reference points lead to a high degree of uncertainty concerning the utility strategic counterparts derive even from given strategy combinations. Thus social projection, although error-prone in some situations, might be a justified short-cut for dealing with strategic uncertainty of higher orders.

(3) *Entrepreneurs' coordination behavior does not differ significantly from that of students.*

In Article 1, Article 2 and Article 4, entrepreneurs and non-entrepreneurs have been compared with respect to their behavior under strategic uncertainty. No significant differences in coordination behavior of entrepreneurs and non-entrepreneurs have been found. In particular, Article 4 shows that entrepreneurs do not act more on their confidence in relative skills than non-entrepreneurs. The conclusion derived from this is that it is not a pronounced level of relative overconfidence that distinguishes entrepreneurs from non-entrepreneurs. This result is in line with the growing evidence that excess market entry is rather caused by the nature of the decision environment and by the way people learn in an uncertain environment than by entrepreneurs being particularly overconfident. The sample sizes in these studies were relatively small. Thus small differences might not have been detected in our studies. The fact that we find large and highly significant gender differences suggests, however, that compared to the effect of gender between entrepreneurs and non-entrepreneurs are negligible.

(4) *Gender differences are more important for strategic decision making in a competitive decision scenario than differences between entrepreneurs and non-entrepreneurs.*

In Article 2 we investigate whether gender differences observed in strategic decision making after gains and losses are smaller between male and female entrepreneurs than between male and female non-entrepreneurs. Contrary to our expectation that self-selection and the "training" in competition would lead to smaller gender differences with entrepreneurs, the gender gap in behavior largely remains with male and female entrepreneurs. The results on entry into skill-based competition in Article 4 point into the same direction: here as well, gender has a significant effect on behavior while being an entrepreneur does not. Together these results indicate that gender effects outweigh the effect of being an entrepreneur in strategic decision making. This finding has two interesting implications for research on female entrepreneurs and the participation of gender differences: (a) female entrepreneurs are not necessarily more willing to take strategic uncertainty than other women. Aspects that might help female entrepreneurs to overcome their reluctance to enter skill-based competition might be related to different motivations of male and female entrepreneurs that have been reported by surveys in female entrepreneurship. (b) The observed gender differences in entry decisions are large while differences between entrepreneurs and non-entrepreneurs are insignificant. This implies that gender specific research on entrepreneurship and affirmative action warrant further exploration and have the potential to have a large impact on entrepreneurial activity.

1.4 Conclusions

This dissertation comprises four experimental studies that investigate decision making under simultaneously existing strategic and exogenous uncertainty. Entrepreneurs' and non-entrepreneurs' decision making in this context has been compared. The core results suggest that people might rely on rather simple heuristics when coordinating under dual uncertainty. Two aspects that might play a role in these mental short-cuts are payoffs asymmetries and social project. Future research should investigate the connection between payoffs asymmetries and social project, on the one hand, and the consolidating results on risk dominance, on the other hand. This might explain why risk dominance often accounts very well for decision making under strategic uncertainty of higher order even though this concept requires a sophisticated calculus. Furthermore, results indicate that exogenous demand uncertainty amplifies the overentry observed in small markets and the underentry in large markets. This gives rise for further research on the influence of exogenous demand uncertainty on entry behavior in different types of markets. Comparing entrepreneurs and non-entrepreneurs no significant differences in strategic decision behavior have been found. This result adds to the growing evidence that entrepreneurs might not be so different from others after all and that excess market entry is rather caused by the nature of the decision environment and by the way people learn in an uncertain environment than by entrepreneurs being particularly overconfident. Instead, results show significant gender differences in strategic decision making that remain within the group of entrepreneurs. The result that gender is important and being an entrepreneur does not significantly impact on strategic decision making supports specific research on female entrepreneurship.

References

Acs, Z., Audretsch, D., Desai, S., and Welpe, I., 2010. "On experiments in entrepreneurship research". *Journal of Economic Behavior and Organization*, 76, 1-2.

Biel, A., and Gärling, T., 1995. "The role of uncertainty in resource dilemmas". *Journal of Environmental Psychology*, 15, 221-233.

Bolger, F., Pulford, B.D., and Colman, A.M., 2008. "Market Entry Decisions: Effects of Absolute and Relative Confidence". *Experimental Psychology*, 55, 113-120.

Brandts, J. and Yao, L., 2010. "Ambiguous information and market entry: an experimental study". MPRA Working paper 25276.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1990. "Resource dilemmas with environmental uncertainty and asymmetric players". *European Journal of Social Psychology*, 20, 475-487.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1992. "Simultaneous vs. Sequential Requests in Resource Dilemmas with incomplete information". *Acta Psychologica*, 80, 287-310.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1995a. "Common pool resource dilemmas under uncertainty: Qualitative tests of equilibrium solutions". *Games and Economic Behavior*, 10, 171-201.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1995b. "Positional order and group size effects in resource dilemmas with uncertain resources". *Organizational Behavior and Human Decision Processes*, 61, 225-238.

Burmeister, K., and Schade, C., 2007. Are entrepreneurs' decisions more biased? An experimental investigation of the susceptibility to status quo bias. *Journal of Business Venturing*, 22, 340-362.

Busenitz, L.W., and Barney, J.B., 1997. "Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making". *Journal of Business Venturing*, 12, 9-30.

Cabrales, A., Nagel, R., and Armenter, R., 2007. "Equilibrium selection through incomplete information in coordination games: an experimental approach". *Experimental Economics*, 10, 221-234.

Camerer, C. and Lovallo, D., 1999. "Overconfidence and excess entry: an experimental approach". *The American Economic Review*, 89, 306-318.

Camerer, C., Ho,T.-H., and Chong, J.-K., 2004. "A cognitive hierarchy model of games". *The Quarterly Journal of Economics*, 3, 861-898.

Carlsson, H., and van Damme, E.E., 1993. "Global games and equilibrium selection". *Econometrica*, 61, 989-1018.

De Vries, S. and Wilke, H.A.M., 1995. "An advisor in resource management situations. Configural weighing of recommendations". *Journal of Economic Psychology*, 16, 115-135.

De Vries, S., and Wilke, H.A.M., 1992. "Constrained egoism and resource management under uncertainty". In W.B.G. Liebrand and D. M. Messick (Eds.), *Social dilemmas: Theoretical issues and research findings*, 81-100. Oxford, UK: Pergamon Press.

Dickinson, D.L., 1998. "The voluntary contributions mechanism with uncertain Group Payoffs". *Journal of Economic Behavior and Organization*, 35, 517-33.

Elston, J.A., Harrison, G., and Rutström, E.E., 2006. "Experimental Economics, Entrepreneurs and the Entry Decision". UCF Working Paper.

Franke, N., Gruber, M., Harhoff, D., and Henkel, J., 2006. "What you are is what you like – similarity biases in venture capitalists evaluation of start-up teams". *Journal of Business Venturing*, 21, 802-826.

Gangadharan, L. and Nemes, V., 2009. "Experimental Analysis of Risk and Uncertainty in Provisioning Private and Public Goods". *Economic Inquiry*, 47, 146-164.

Gong, M., Baron, J., and Kunreuther, H., 2009. "Group cooperation under uncertainty". *Journal of Risk and Uncertainty*, 39, 251-270.

Heinemann, F., Nagel, R., and Ockenfels, P., 2004. "The theory of global games on test: experimental analysis of coordination games with public and private information". *Econometrica*, 72, 1583-1599.

Heukelom, F., 2007. "Who are the Behavioral Economists and what do they say?". Tinbergen Institute Discussion Paper, TI 2007-020/1.

Kahneman, D., and Tversky, A., 1979. "Prospect Theory: An Analysis of Decision under Risk". *Econometrica*, 47, 263-292.

Karelaia, N., and Hogarth, R., 2010. "The attraction of uncertainty: Interactions between skill and levels of uncertainty in market-entry games". *Journal of Risk and Uncertainty*, 41, 141-166.

Levati, V., Morone, A., and Fiore, A., 2009. "Voluntary contributions with imperfect information: An experimental study". *Public Choice*, 138, 199-216.

Messick, D.M., Allison, S.T., and Samuelson, C.D., 1988. "Framing and communication effects on group members' responses to environmental and social uncertainty". In S. Maital (Ed.), *Applied Behavioural Economics*, 2, 677-700. New York: New York University Press.

Niederle, M., and Vesterlund, L., 2011. "Gender and Competition". *Annual Review in Economics*, 3, 601-630.

Parlich, L.E., and Bagby, D.R., 1995. "Using cognitive theory to explain entrepreneurial risk-taking: challenging conventional wisdom". *Journal of Business Venturing*, 10, 425-438.

Pogrebna, G. and Schade, C., 2009. "Innovation, Entry into Multiple Markets and Unobserved Heterogeneity". SSRN working paper 1374409.

Rapoport, A. and Au, W.T., 2001. "Bonus and penalty in common pool resource dilemmas under uncertainty". *Organizational Behavior and Human Decision Processes*, 85, 135-165.

Rutte, C.G., Wilke, H.A.M., and Messick, D.M., 1987. "Scarcity or abundance caused by people or the environment as determinants of behavior in the resource dilemma". *Journal of Experimental Social Psychology*, 23, 208-216.

Sandri, S., Schade, C., Mußhoff, O., and Odening, M., 2010. "Holding on for too long? An experimental study on inertia in entrepreneurs' and non-entrepreneurs' disinvestment choices". *Journal of Economic Behavior and Organization*, 76, 30-44.

Schade, C., 2010. "Entrepreneurial decision making: A paradigm rather than a set of questions Introduction to special section based on Lally–Darden–Humboldt Young Entrepreneurship Scholars' Retreat 2006“. *Journal of Business Venturing*, 25,173-174.

Schade, C., and Burmeister-Lamp, K., 2009. "Experiments on entrepreneurial decision making: A different lens through which to look at Trends in Entrepreneurship". *Foundations and Trends in Entrepreneurship*, 5, 81-134.

Schade, C., Schroeder, A., and Krause, K., 2010. "Coordination after gains and losses: Is prospect theory's value function predictive for games?" *Journal of Mathematical Psychology*, 54, 426-445.

Simon, M., Houghton, S.M., and Aquino, K., 2000. "Cognitive biases, risk perception, and venture formation: How individuals decide to start companies". *Journal of Business Venturing*, 15, 113-134.

Suleiman, R., and Rapoport, A., 1988. "Environmental and Social Uncertainty in Single-Trial Resource Dilemmas". *Acta Psychologica*, 68, 99-112.

Tversky, A., and Kahneman, D., 1974. "Judgment under uncertainty: Heuristics and biases". *Science*, 185, 1124-1131.

Weitzel, U., Urbig, D., Desai, S., Sanders, M., and Acs, Z., 2010 "The good, the bad, and the talented: Entrepreneurial talent and selfish behavior". *Journal of Economic Behavior and Organization*, 76, 64-81.

Wit, A. and Wilke, H.A.M., 1998. "Public good provision under environmental and social uncertainty". *European Journal of Social Psychology*, 28, 249-256.

2. Coordination under dual uncertainty

Article 1:

Coordination under dual uncertainty: Comparing mixed strategy equilibria, risk dominance, and a decision heuristic

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This paper investigates coordination behavior in a two-player game with dual uncertainty, i.e., strategic uncertainty and exogenous payoff uncertainty. Coordination behavior is compared with mixed strategy equilibria, with equilibrium selection based on risk dominance, and with a plausible decision heuristic. In the most satisfactory model, investment probability varies linearly with each player's cost. We interpret this as a heuristic based on the player's cost and on social projection. Exploring the generalizability of our results, we found no evidence of behavioral differences between students and high-tech entrepreneurs who are confronted with dual uncertainty in their profession.

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2.1 Introduction

Behavioral game theory is concerned with interactive decisions behavior of interdependent decision makers. Uncertainty is considered to be strategic. Behavioral decision theory instead considers individual decision making or ‘games against nature’ and treats uncertainty as exogenously given. While this distinction between strategic uncertainty and exogenous uncertainty has widely separated the literature on behavioral game theory and behavioral decision theory, a growing number of studies investigate behavior in games that involve stochastic payoffs where uncertainty stems from both strategic and exogenous sources. The aim hereby is to understand how exogenous uncertainty influences strategic decision making.

Most studies in this domain examine resource dilemmas and public goods games where the size of the resource or the provision point of the public good is uncertain (Rutte et al. 1987, Suleiman and Rapoport 1988, Messick et al. 1988, Budesu et al. 1990, 1992, 1995a, 1995b, De Vries and Wilke 1992, 1995, Biel and Gärling 1995, Wit and Wilke 1998, Rapoport and Au 2001, Levati et al. 2009, Gangadharan and Nemes 2009). Gong et al. (2009) analyze group cooperation in a prisoner’s dilemma with stochastic payoffs. Only very few studies have analyzed coordination behavior under dual-uncertainty (e.g., Cabrales et al. 2007). Cabrales et al. (2007) examine a coordination game with dual-uncertainty where noisy signals about the true payoffs lead to a unique Nash-equilibrium. Other authors have investigated coordination in market entry games with uncertain payoffs (Brandts and Yao 2010, Karelaia and Hogarth 2010).

This paper contributes to the literature on coordination under dual-uncertainty by testing established game theoretic concepts – the mixed strategy equilibrium and the risk dominance criterion – against a plausible decision heuristic.

For classic coordination games that only involve strategic uncertainty, the explanatory power of the mixed strategy equilibrium and equilibrium selection concepts such as payoff dominance and risk dominance (Harsanyi and Selten 1988) has been debated because results are mixed (e.g., Cooper et al. 1990, Crawford 1991, Straub 1995, Ochs 1995, Schmidt et al. 2003, Sundali et al. 1995, Van Huyck et al. 1990, Cabrales et al.

2000, Février and Linnemer 2006). For non-strategic individual decisions under exogenous uncertainty, people have often been found to use decision heuristics rather than sophisticated utility maximizing calculus (e.g., Tversky and Kahneman, 1974, Kahneman et al. 1982, Payne et al. 1993, Thomas and McFadyen 1995, Gigerenzer et al. 1999). But although the idea that people use heuristics is widely accepted in individual decision making, only few studies have tested the empirical relevance of heuristics in games (e.g., Leland, 2006, Deventag and Di Guida 2010). Given the results on individual decision making under uncertainty, it is plausible to assume that people also use decision heuristics when coordinating under dual-uncertainty where payoffs are subject to strategic and exogenous uncertainty.

We study coordination behavior under dual-uncertainty in a two-player coordination game with asymmetric, risky payoffs. To explore the generalizability of our findings we ran economic experiments with students – the group most widely considered in studies on coordination behavior – and high-tech entrepreneurs who regularly encounter decisions under dual-uncertainty in their profession. Testing the explanatory power of mixed strategy equilibria, risk dominance, and a decision heuristic against each other required setting up a 'realistic' decision situation that was still parsimonious enough to apply equilibrium and equilibrium selection concepts. Giving the group of high-tech entrepreneurs a possibility to connect to their experiences with dual-uncertainty we chose to analyze a coordination game that is framed as a research and development investment scenario. The outcomes in this game depended on strategic uncertainty arising from two interacting decision makers' choices and exogenous uncertainty about the outcome of the investment. Coordination behavior in this game was compared to the predictions of mixed strategy play, risk dominance and a decision heuristic that is based on simple cost considerations and social projection. We find that the most satisfactory model in our comparison assumes linear relations to each player's cost and is consistent with the proposed heuristic model. We discuss the plausibility of this behavioral concept. Behavioral differences between students and entrepreneurs are surprisingly small and not statistically significant.

The remaining paper is organized as follows: in the next section the game underlying the experiment is analyzed and hypotheses are derived. In section three the experiment is described. In section four we present the analysis and results. The findings are discussed in section five. Section six contains the conclusion.

2.2 Coordination game with dual uncertainty

The decision scenario for our experiment is based on the general interdependent security model of Heal and Kunreuther (2005). The game involves exogenous uncertainty concerning success of research and development and concerning success of free-riding which leads to stochastic payoffs. Strategic uncertainty is based on possible research investments by others.

2.2.1 Game

In the game, two players have to decide simultaneously and without being able to observe the other's choice whether or not to invest into a putative research and development project. The project will generate an innovative technology with a stated success probability p_1 and p_2 for Player 1 and Player 2, respectively. Investing in the project results in cost c_1 for Player 1 and c_2 for Player 2, where $c_1 \neq c_2$. Both players have an initial endowment Y, incurred costs are deducted from Y and realized gains are added to Y. Success yields a monetary gain G. Thus, the profits from investing are uncertain: the expected gains from the players' own investments are $p_1 G - c_1$ and $p_2 G - c_2$, respectively. Additionally, players face technological spillovers. With a spillover probability q_2 Player 2 will gain G from a successful investment by Player 1, by copying or imitating the innovation. Thus, if Player 2 does not invest or does not succeed, but Player 1 does invest, Player 2 obtains G nonetheless by copying, with probability $q_2 p_1$ (probability that Player 1 succeeds and then Player 2 copies successfully). Technological spillover exists in both directions, i.e., Player 1 is also able to copy from Player 2. Copying is assumed costless and therefore occurs whenever possible. This leads to bilateral free-riding incentives. Thereby, the solution that nobody invests in research can be worst for both players, but at the same time neither player wants to be the one investing. This general incentive structure is shared with the Chicken game, which has received attention in economics as well as political science. In the scenario modeled here, spillover and success uncertainty modify the incentives. Letting I denote the strategy to invest in the project and let N denote the strategy not to invest, we obtain the following two-player matrix of expected payoffs:

TABLE 1. MATRIX OF EXPECTED PAYOFFS

		PLAYER 2: I	PLAYER 2: N
PLAYER 1	I	$Y-c_1+p_1G+(1-p_1)q_1p_2G$ $Y-c_2+p_2G+(1-p_2)q_2p_1G$	$Y-c_1+p_1G$ $Y+q_2p_1G$
	N	$Y+q_1p_2G$ $Y-c_2+p_2G$	Y Y

The entries in each cell of this matrix are the expected values for Player 1 (above) and Player 2 (below). They are readily derived following through the logic sketched in the preceding paragraph. Implicit in this model are certain simplifying assumptions, e.g., that copying by one player does not reduce the other's payoff and that copying costs can be neglected. The former assumption might be valid if the two players want to use the new technology in different markets. When investment costs for both players are neither low enough to justify investing even if the counterpart player invests as well nor higher than the expected payoff from investing, i.e., $(1-q_ip_j)p_iG<c_i<p_iG$, the game has two pure strategy Nash equilibria and thereby induces a coordination problem. As we are interested in coordination behavior, we limit our analysis to these intervals of c_1 and c_2. Stochastic payoffs lead to dual uncertainty and make our decision situation reflective of numerous situations that decision makers face outside the laboratory. Outcomes are uncertain even if the strategy vector is given. Nash equilibria are derived by assuming that players choose strategies in accordance with the expected payoffs from these strategies.

2.2.2 Nash equilibria and mixed-strategy play

For $(1-q_1p_2)p_1G<c_1<p_1G$ and $(1-q_2p_1)p_2G<c_2<p_2G$, the game has the two pure strategy Nash equilibria (I,N) and (N,I). For the intervals of c_1 and c_2

satisfying the above inequalities, only one player should invest and the other player should try to copy[2]. Since copying is costless, the expected payoff is higher for the player who plays N in each of these equilibria: neither wants to be the one who invests in innovation, rather, both prefer to speculate on being able to free-ride.

There is also a mixed-strategy equilibrium $(\widetilde{m}_1, \widetilde{m}_2)$. Suppose that each player chooses a mixed strategy, and let m_i be the probability that Player i invests, for i = 1, 2. The mixed-strategy equilibrium for this game is given by

$$\widetilde{m}_i = \frac{p_j G - c_j}{q_i p_i p_j G} \tag{1}$$

At equilibrium, each mixing probability depends only on the counterpart player's cost c_j, not on the player's own cost c_i. Previous studies have reported on coordination behavior converging to the mixed strategy equilibrium after a sufficient number of rounds and on aggregate behavior that is close to the mixed strategy equilibrium (e.g., O'Neill 1987, Mookherjee and Sopher 1994, McCabe et al. 2000). With hypothesis 1 we test whether coordination behavior in the given one-shot dual-uncertainty scenario can be described by mixed strategy play:

HYPOTHESIS 1: Peoples' investment decisions are related to the mixed strategy equilibrium probabilities.

Analyzing the data, we translate this hypothesis into a hierarchy of models (model family 1), including a 0-parameter model in which the players' investment probabilities are simply compared to the mixed strategy equilibrium values. Such a strict 0-parameter model does not allow for individual biases. To assess the value of the different concepts for describing behavior, we embedded the concepts into linear models that do allow for biases and initial propensities to invest. These models parsimoniously add additional parameters which capture initial investment propensities by intercept α and gradual reactions to the factors *mixed strategy equilibrium* (hypothesis 1), *risk dominance* (hypothesis 2), and *own cost* and *counterparts cost* (hypothesis 3) by slopes β and γ.

[2] For a general equilibrium analysis see Appendix II.

In addition to the 0-parameter model where the players' investment probabilities are simply compared to the mixed strategy equilibrium values we therefore also considered more complex models in which players' investment probabilities are fitted by different linear functions of the mixed strategy equilibrium values.

2.2.3 Equilibrium selection

As players have different preferences, the two pure-strategy equilbria in this coordination game cannot be Pareto ranked[3]. When selecting between equilibria the payoff dominance criterion thus cannot be applied[4]. Still, the risk dominance criterion is applicable (Harsanyi and Selten 1988). The risk dominance criterion compares the product of the two players' payoff gains from correctly predicting the equilibrium choice of the other player as compared to making a wrong prediction. The equilibrium with the largest risk-product is the one that is risk dominant.

In the considered game, (I,N) is the risk dominant equilibrium if and only if the risk-product of (I,N) is greater than the risk-product of (N,I). Calculating the risk-products for (I,N) and (N,I) from Table 1 leads to the following inequality:

(2) $$(p_1G-c_1)(c_2-p_2G+q_2p_2p_1G)>(p_2G-c_2)(c_1-p_1G+q_1p_2p_1G)$$

Subtracting the later product from the first gives the risk-product difference r_Δ, with

(3) $$r_\Delta = p_1p_2G(c_2q_1-c_1q_2+q_2p_1G-q_1p_2G)$$

Under the assumption (fulfilled in the experiment described below) that $p_1 = p_2$ and $q_1 = q_2$ this expression reduces to

[3] Initial interests in coordination games stem from 'common interests' situations with multiple Pareto rank able Nash equilibria, in which people might get stuck in undesirable outcomes. As a consequence, most studies consider either games with a payoff dominant equilibrium only or they investigate the conflict between payoff dominance and risk dominance (e.g., Van Huyck et al. 1990, Mehta et al. 1994, Cachon and Camerer 1996, Schmidt et al. 2003).

[4] For proof see Appendix III.

(4) $$r_\Delta = qp^2G(c_2 - c_1)$$

The equilibrium (I, N) is risk dominant if and only if the risk-product difference r_Δ is positive, which is the case if and only if $c_1 < c_2$. Accordingly, (N, I) is risk dominant if and only if the risk-product difference r_Δ is negative; i.e., if and only if $c_1 > c_2$. If the risk-product difference r_Δ is zero, the risk dominance criterion does not apply. The equilibrium in which the player with the lower cost invests and the player with the higher cost does not invest but hopes to be able to free-ride is risk dominant when success and copying probabilities are equal for both players. The predictive power of the risk dominance criterion has received empirical support in coordination games with strategic complements (e.g., Cabrales et al. 2000, Schade et al. 2010). It has been also found to account well for behavior in a global game (Cabrales et al. 2007). With hypothesis 2 we test whether this result also holds for coordination behavior in the considered dual-uncertainty game.

HYPOTHESIS 2: People's decisions follow risk dominance, i.e., investment decisions vary linearly with the sign of the risk-product difference r_Δ.

A strict 0-parameter model would postulate that the risk-dominant equilibrium is always chosen; i.e., investment probability $I = 100\%$ for the player with lower cost and probability $I = 0\%$ for the player with higher cost. A slightly more general 2-parameter model would assert that the investment probability takes two different values: a high value if the player's own cost is lower than his opponents cost and a lower value if the player's own cost is higher than the opponent's cost. Another variant might be a 2-parameter model in which the investment probability is a linear or a log-linear function of r_Δ. For the current experiment, however, the risk-product difference r_Δ is constant, and so this latter variant reduces to the model with only two probability values, i.e., to a linear function of the sign of r_Δ. As in the case of *hypothesis 1*, we translate the risk dominance concept into a hierarchy of linear models with varying numbers of parameters for individual subjects for the analysis.

2.2.4 Cost heuristic plus social projection

Coordination under dual uncertainty is more complex than in "standard" coordination games. It involves additional uncertainty from exogenous sources and the payoffs are probabilistic even if strategy choices of all players are given. Dealing with exogenous uncertainty in non-strategic decision scenarios, people have been found to often use of heuristics (e.g., Kahneman and Tversky 1974, Kahneman et al. 1982, Payne et al. 1993, Thomas and McFadyen 1995, Gigerenzer et al.1999). As an alternative to mixed strategy equilibria and the risk dominance criterion we thus test whether peoples' decisions in our dual-uncertainty scenario can be explained by a heuristic.

In the considered game, a plausible decision heuristic is based on *cost*, a crucial aspect of any investment decision. The higher the up-front cost the less attractive the investment, all else equal. Hence, cost affects investment propensity. Furthermore, in coordination games, "all else" is not equal, because players do not know what their counterparts will do. We propose that a decision maker fills this gap, not by assuming rationality of the other player but by assuming that the counterpart will follow a decision rule similar to her own: to invest less frequently when faced with high investment cost and more frequently with low. This is consistent with social projection. Social projection as a means to build beliefs about other's behavior is a widely accepted concept in social psychology (Allport 1924, Festinger 1954, Orive 1988, Krueger, 2000, 2007). It has been introduced into the equilibrium analysis with coordination games by Schade et al. (2010); behavior in such games has been reported to be consistent with a prediction based on social projection for many respondents. Since in our scenario it is better to invest oneself than to face a situation where nobody does so, investment propensity should also be higher when a player projects that his counterpart is unlikely to invest. Investment propensity should thus be a decreasing function of the player's own cost and an increasing function of the counterpart's cost. This leads us to a third hypothesis:

HYPOTHESIS 3: People's decisions follow simple cost considerations and social projection; i.e., they vary negatively with the decision makers' own cost and positively with the opponent's cost.

2.3 Experiment

2.3.1 Participants

The experiment was conducted with students – the typical group of subjects in most of the previous studies on coordination behavior – as well as with a group of high-tech entrepreneurs who are typically confronted with dual-uncertainty in their profession. We assumed that most high-tech entrepreneurs would have faced similar research and development investment decisions in their professional lives already or at least have thought about such a situation before. By comparing these two groups, we explore the generalizability of our findings in terms of describing real decision makers' behavior. This is important as previous research has reported on a number of differences in the decision making of entrepreneurs as compared to others (e.g., Cooper et al. 1988, Baron 1998, Busenitz and Barney 1997). The differences in entrepreneurs' decision behavior have been discussed to be a consequence of dealing with a high degree of uncertainty and time pressure in their profession. Thus, they might play a role for dealing with dual-uncertainty as well.

Our sample consisted of 56 participants, 38 business and economics students and 18 entrepreneurs from the high-tech industry. Students were recruited at the School of Business and Economics at a German university. Entrepreneurs were recruited in a large science and technology park. We conducted six sessions; entrepreneurs and students played in separate sessions. The student sessions were conducted in the experimental laboratory at their university. The entrepreneur sessions were partially conducted in the same experimental laboratory. Partially they were conducted using a mobile laboratory that was set up at the science and technology park. Entrepreneurs were aware of the fact that they played against other entrepreneurs. The average age of the students was 24 years. Of the students 17 were male and 21 female. 20 had majored in business and management, 11 in economics, and the rest in mathematics or computer science with a minor in economics. 22 stated that they were trained in game theory. Of the student participants five had previously participated in an economic experiment but not in a similar one or more than twice, and none in a psychological experiment. The rest had never participated in any kind of experiment before. The average age of the entrepreneurs was 41.9 years. 14 of them were male and 4 were female. All were founders and managers of high-tech companies. On average, they had been active in their current business for 9.5 years. Most held a university degree; two of them held a Ph.D. None of the entrepreneurs had previously participated in an economic or psychological experiment and none indicated prior knowledge of game theory.

2.3.2 Incentives

To assure incentive compatibility, monetary compensation depended on the participant's performance in the experimental task. Throughout the experiment we used the experimental currency 'Talers', with 10,000 Talers equal 1 € for the students and 4.50 € for the entrepreneurs. At 15 € per hour, the average student payoff was close to a student assistant hourly salary. Entrepreneurs' payoffs were scaled up by a factor of 4.5 to account for the income differential between the two groups.

2.3.3 Experimental design and procedure

The experiment was programmed and conducted using the software z-Tree (Fischbacher 2007). We considered the coordination game modeled in section two, focusing on selected cost combinations (see Figure 1 below) that lead to two pure Nash equilibria in (I,N) and (N,I). Each session took approximately 60 minutes, including 15 minutes for instructions.

On their arrival at the laboratory, participants were placed at separated computer desks. Experimental instructions (in German) were presented via computer screens, individually for each participant. Instructions were also read aloud to the participants at the beginning of each session. Additionally, printed copies of instructions were handed out: participants could easily go back if they missed a detail. An English translation of the instructions can be found in Appendix V. After the general instructions, each participant was matched with an anonymous counterpart. Matching was conducted randomly by the computer and remained fixed throughout the experiment. Participants played 9 rounds of the coordination game. In each round, they decided whether or not to invest into a certain research and development project, at a stated cost, knowing that the counterpart was simultaneously confronting the same decision, and knowing the counterpart's cost. Success probability for the project was set to 0.30 for both players. A player who did not invest in one round nevertheless received the gain by copying, with probability 0.80, provided that the counterpart had invested successfully in that round. The copying occurred automatically, with no additional decision step. Due to the simultaneous move, players were unable to observe their counterparts' decisions, leading to a need for coordination. To avoid learning effects, participants did not receive between-round feedback. Instead, feedback about the outcome of each round was given in form of a result list at the end of the experiment. In each round, the players faced a different individual cost levels. In some rounds, a player's own investment cost was lower than the counterpart's investment cost and it was higher in other rounds. Figure 1 shows the different cost combinations that were presented to the two players. The presentation order of these paired costs was randomized for each pair of players.

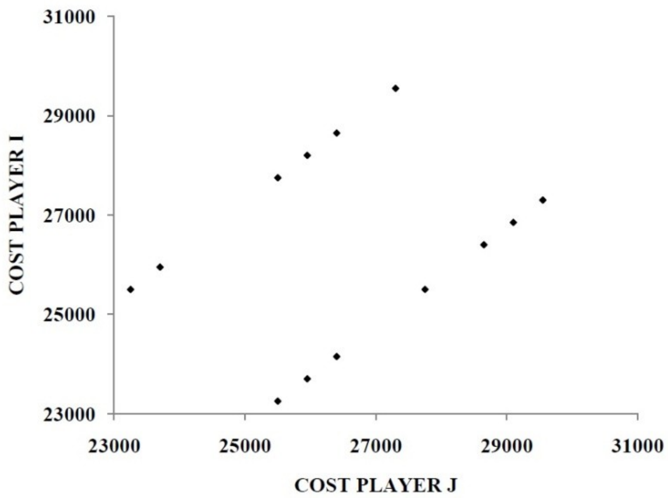

FIGURE 1. COST COMBINATIONS

In some rounds, the player's own cost was lower than his opponent's cost; in other rounds his cost was higher than his opponent's cost. Still, for each round the difference between the costs of both players was constant at 2,250[5]. There are 13 different values for a player's own cost. 10 of these values occur only once per dyad while three of these values (25,500; 25,950; 26,400) occur twice per dyad – once paired with an opponent's cost of +2,250 and once paired with an opponent's cost of -2,250 (see also Table 5 in Appendix I). Participants were not confronted with all 13 values for own cost but with 8 values making the design complete for dyads and not for individuals. As will be shown

[5] One round accidently presented a cost difference of 450 (respective cost combination: $c_1 = 26850$; $c_2 = 26400$). We excluded this one round from the analysis.

in the results section, these three double paired cost values generate important evidence against the mixed strategy model.

All other parameters were kept constant: the monetary gain G from using the innovative technology was 100,000 Talers, as was the initial endowment Y. Even though the amount of the initial endowment Y does not make a difference for the game-theoretic analysis we chose to endow participants with a positive amount from which investments could be made so that negative payoffs were impossible. This also allowed them to judge investment costs not only relative to expected gains but also in terms of affordable loss aspects. The success probability p was set to 0.30, mirroring the low success rates predominating in most industries. The spillover probability q was set to 0.80 to achieve high strategic interdependence. All parameters, including the cost level of a player's counterpart, were common knowledge and announced in each round of the game.

Participants were able to state their responses as investment probabilities making use of a randomizing device similar to Anderhub et al. (2002) and Schade et al. (2010). In each round, participants could determine the number of white balls in a bingo cage containing a total of 100 black and white balls. From this bingo cage the computer randomly drew one ball to determine whether or not the investment was executed: when the ball was white the investment was executed; when it was black the respective player did not invest. This procedure is called explicit randomization in the literature (cf. Camerer 2003). We used this response mode in order to allow comparisons with mixed strategy equilibria. Furthermore, this response mode allowed participants to state attitudes towards investing instead of only having the possibility to make 'yes or no' decisions.

Following the experimental task, risk attitudes were measured in accordance to Holt and Laury (2002)[6] and demographic data were gathered. At the end, one round was randomly chosen for each participant. The payoff achieved by the participant in this round determined the payoff from the experimental task. By adding the payoff from the

[6] Risk attitude measures from the Holt and Laury measurement did not have an influence on behavior in our experiment. Results can be requested from the authors.

Holt and Laury (2002) test, the total payoff was calculated and paid out anonymously to the participants at the end of each session.

2.4 Results

2.4.1 Analysis

We analyze the data in three steps: First, we test the three competing hypothesis separately to evaluate the explanatory power of each of the presented concepts. Second, we compare the explanatory power of these concepts to identify which of them performs best. Third, the question of generalizability of the findings is addressed by comparing the coordination behavior of students and high-tech entrepreneurs.

The total dataset consists of 38 students and 18 entrepreneurs. For the main linear modeling, we excluded 11 participants because they made the same decision in all rounds; eight from the students sample and three from the entrepreneurs sample. Six students always stated an investment probability of 1. The other two students stated an investment probability of 0 in each round. One entrepreneur indicated an investment probability of 1 over all rounds, a second indicated a constant investment probability of 0.50, and the third always specified a probability of 0.10. One further participant was excluded from the entrepreneurs' sample because he was a top manager but did not hold any shares in the company at the time the experiment was conducted. The analysis presented below thus used a dataset consisting of 30 students and 14 entrepreneurs. Although the above subjects were not included in the modeling, we consider this group important in thinking about conclusions and we return to them in the discussion section.

2.4.2 Mixed-strategy equilibria – Hypothesis 1

For testing Hypothesis 1, we specify possible models as subfamilies of Model 1:

(5) $$y_{it} = \alpha_i + \beta_i m_{it} + \varepsilon_{it} \qquad \text{(Model family 1).}$$

Here, y_{it} denotes the response (investment probability, ranging from 0% to 100%) for subject i on trial t. m_{it} is the mixed strategy equilibrium probability of Player i on trial t

which dependents on the opponent's cost c_{jt} on that trial. Coefficient α_i is the intercept, which can be thought of as the i^{th} individual's propensity to invest when $m_{it} = 0$, i.e., when expected gain pG falls to the level of investment cost. The slope β_i represents the weight for the i^{th} player on mixed strategy equilibrium probabilities. Finally, ε_{it} is an error term.

This family of models has two components of individual variation, intercepts and slopes. Important special cases arise when one or both of these have zero variance, i.e., $\alpha_i = \overline{\alpha}$ or $\beta_i = \overline{\beta}$ or both. Two important sub-cases involve slope zero $(y_{it} = \alpha_i + \varepsilon_{it})$ and slope one with intercept zero $(y_{it} = m_{it} + \varepsilon_{it})$. This last is a 0-parameter model in which (apart from random error) the investment probability of each player in each round matches the equilibrium mixed strategy. Note that this general model family has 2 parameters per subject, leaving 6 *df* for error, and thus, across 44 subjects, we estimate 88 parameters, with 264 *df* for error. Treating either of the two variance components as null eliminates 43 parameters. Setting all slopes to 0 drops an additional parameter, while $(y_{it} = m_{it} + \varepsilon_{it})$ eliminates all parameters. For the general model family we estimated a linear model for each subject, using least squares, via the lm( ) function in R. Special cases were similarly estimated across subjects using the same method.

Findings – Figure 2 shows the number of parameters (bold), the residual *df* and residual sum of squares (italic) for each of the sub-models mentioned above, together with the appropriate model comparisons, taking into account the nesting of the various sub-models. The arrows show model nesting (less to more general). A dotted arrow indicates that models are non-nested. Differences in residuals and corresponding F statistics accompany some arrows.

The best model is the model with individual intercepts and zero-slope $(y_{it} = \alpha_i + \varepsilon_{it})$. The residual standard deviation from that model is 36.7; scarcely greater than the residual from the most general model (36.2). The strict game-theoretic model with zero-prarameters ($y_{it} = m_{it} + \varepsilon_{it}$; *RSS* = 856893) fits worse in terms of residual sum of squares than the 1-parameter model ($y_{it} = \alpha_i + \varepsilon_{it}$; *RSS*= 577047).

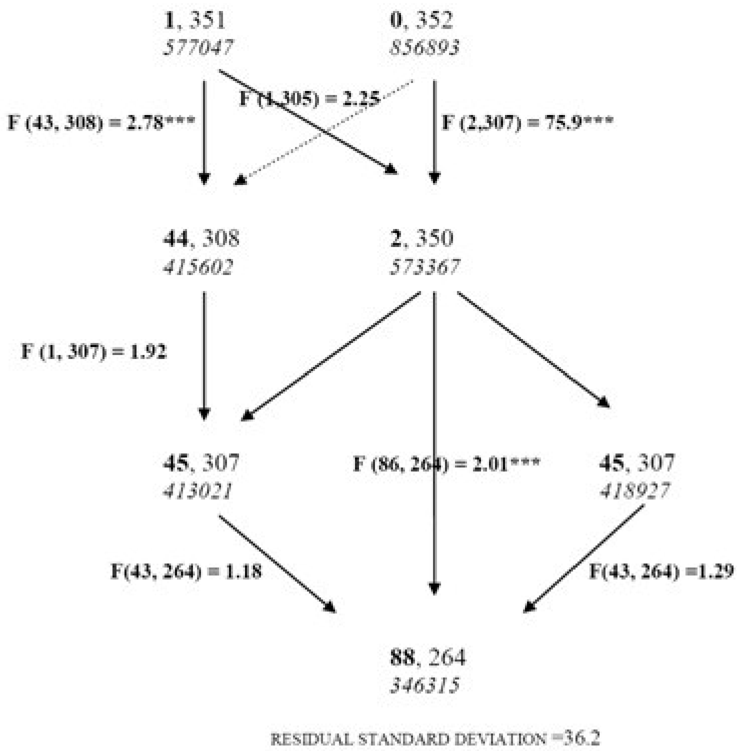

FIGURE 2. MODEL COMPARISONS – MIXED STRATEGY MODEL

From the comparisons of the constant-slope model and the constant-intercept model with the full model we conclude that the slope component of individual variation might be null, while the intercept component cannot be. Moreover, the hypothesis of zero slope cannot be rejected. Consistent with this we find that the slope estimates from the full model do not reject the hypothesis of zero mean, t = -1.38, df =43.

Hypothesis 1 is rejected; the best model within this model family is the 0-slope model with individual intercept $(y_{it} = \alpha_i + \varepsilon_{it})$. In this model, mixed-strategy equilibria play no role at all.

2.4.3 Risk dominance criterion – Hypothesis 2

In accordance to the *risk dominance criterion*, Player *i* should decide to invest into the R&D project, when investing (pure strategy "*I*") is the risk dominant strategy and not to invest when not-investing (pure strategy "*N*") is risk dominant. Thus we assume a general model in which the probability y_{it} of investing is a linear function of the *risk-product difference* r_Δ:

(6) $$y_{it} = \alpha_i + \beta_i r_{\Delta t} + \varepsilon_{it}$$ (Model family 2).

where $r_\Delta = qp^2G(c_j - c_i)$ is positive if and only if $c_i < c_j$ and negative if and only if $c_i > c_j$, respectively. Coefficient α_i is the intercept, which can be thought of as the ith individual's propensity to invest when $r_\Delta = 0$, i.e., when $c_i = c_j$. The slope β_i represents the weight for the i[th] player on risk dominance r_Δ.

As in the case of hypothesis 1, this family of linear models has two components of individual variation, and most of the analogous sub-models make sense: constant intercept, constant slope, or both. An important sub-case involves slope zero where risk dominance has no effect $(y_{it} = \alpha_i + \varepsilon_{it})$. The strict 0-parameter sub-model $y_{it} = r_{\Delta t} + \varepsilon_{it}$ states that the investment probability is either 0 or 100%, depending on which cost is lower. This can also be written as a special case of equation (5).

The parameters and nesting status of the sub-models in model family 2 parallel the ones in model family 1 above. It is important to note that the 0-slope sub-models $(y_{it} = \alpha + \varepsilon_{it})$ and $(y_{it} = \alpha_i + \varepsilon_{it})$ are identical for model family 1 and model family 2. Thus they are nested in a special case of both full models.

Findings – Equivalent to Figure 2, Figure 3 shows number of parameters (bold), the residual *df* and residual sum of squares (italics) for the relevant sub-models, together with the appropriate model comparisons, taking into account the nesting of the various sub-models.

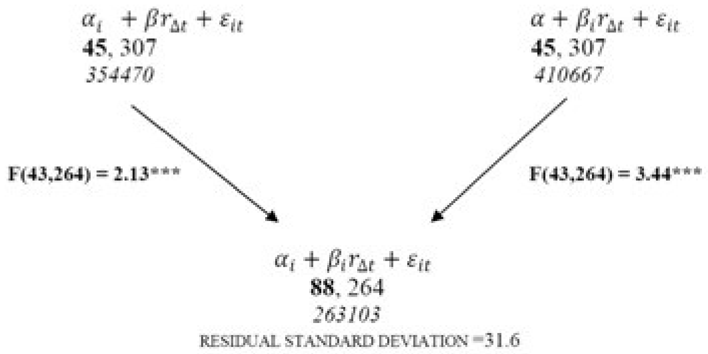

FIGURE 3. MODEL COMPARISON – RISK DOMINANCE MODEL

2.4.4 Cost heuristic plus social projection – Hypothesis 3

Hypothesis 3 states that players following a cost heuristic plus social projection invest more frequently when their own costs are low and when their counterpart's costs are high. This implies a negative effect of own cost and a positive effect of counterpart's cost. Subject i's investment decision y_{it} can be described as a function of own cost c_i and opponent's cost c_j:

$$y_{it} = \alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it} \qquad (7) \quad \text{(Model family 3).}$$

where α_i is the individual intercept, β_i represents the influence of own cost on the investment decision, and γ_i represents the influence of opponents' cost.

For this model we estimated three parameters per subject (3* 44 subjects = 132 parameters; leaving 5 *df* for error per subject). Each of the three components of variation can be tested against the null hypothesis of a coefficient that is constant across subjects, giving rise to a family of sub-models depicted in Figure 4 below. The most important special case in this model family is the full model for Hypothesis 2, which is equivalent to the assumption that all pairs of coefficients for own and counterpart's cost are equal and opposite, i.e., $\beta_i + \gamma_i = 0$ for all *i*.

Findings – Figure 4 shows the residual sum of squares and residual *df* for the full model (132 parameters) and for the four special sub-models testing each component of variance and the *risk dominance* sub-model discussed above.

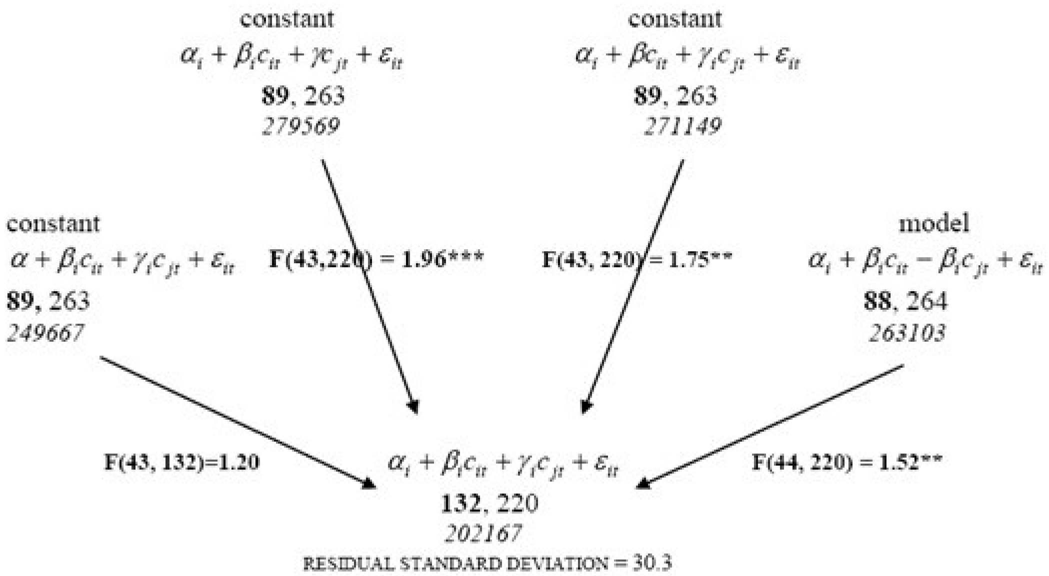

FIGURE 4. MODEL COMPARISON – HEURISTIC MODEL

The best model is most likely the full 132-parameter model. Also tenable is the constant-intercept model: it is not rejected by the F-test but it is not very plausible. The tests of sub-models show that all three components of variance are needed in the model for Hypothesis 3. The comparison with model family 2 (r_Δ model) shows that the hypothesis of symmetric opposite slopes for own and other's cost can be rejected, though statistical significance is less than convincing ($p < 0.05$). Examining the distribution of individual coefficients for own cost β_i we find that the average reaction to own cost is negative: subjects' investment probability decreases with increasing investment cost. The average reaction to counterpart's cost γ_i is positive indicating that investment probability increases when the costs of a player's counterpart increase. Thus, we find support for hypothesis 3: under dual uncertainty coordination behavior can be explained by choosing strategies in accordance to the cost heuristic plus social projection.

2.4.5 Model comparison

In this section we want to answer question which of the concepts (mixed strategy play, risk dominance, or cost heuristic plus social projection) describes individual behavior best. We thus review the explanatory power of the models. Table 2 shows the Multiple R square values for all three models. Values are estimated for the overall 8-round dataset including both students and entrepreneurs. Model 2 is nested in model 3. Model 1 is nested in Model 3 under the assumption that the slope of own cost is zero (for details see Appendix IV). We compare models 1, 2 and 3 via the F-test to provide statistical significance levels for the comparison.

TABLE 2. FIT MEASURES FOR FULL MODELS

	FULL MODELS	MULTIPLE R-SQUARED
M1: Mixed-strategy equilibria	$\alpha_i + \beta_i m_{it} + \varepsilon_{it}$	0.752
M2: Risk dominance criterion	$\alpha_i + \beta_i r_{\Delta t} + \varepsilon_{it}$	0.811
M3: Cost heuristic plus social projection	$\alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$	0.855

The F-test of the comparison between model 3 and model 2 yields $F_{44,220} = 1.51$, $p < 0.05$. The F-test of the comparison between model 3 and model 1 yields $F_{44,220} = 3.56$, $p < 0.001$. Model 1 is included in this comparison taking into account the slope effect as we attempted to be generous in favor of model 1. We feel this is a reasonable comparison. Otherwise, this would have given rise to a comparison between a 44-parameter model and a 132-parameter model, as the condition for nesting model 1 is that the slope is zero. Comparing the full model 3 with the individual incept and zero slope version of model 1 yields $F_{88,220}=2.64$, $p < 0.001$. A comparison between the full model 3 with the constant intercept and zero slope version of model 1 yields $F_{131,220} = 3.11$, $p < 0.001$.

The linear model for mixed strategy play revealed that mixed-strategy equilibrium plays no role at all. This is reflected by the result that model 1 fits the data worst of the three models. Model 3 (cost heuristic plus social projection) exhibits better fit measures than Model 2 (risk dominance). The comparison of model 2 and model 3 shows that the hypothesis of symmetric opposite slopes for own and other's cost can be rejected. Plotting the observed means of investment probability against the predicted mixed strategy equilibrium illustrates the results:

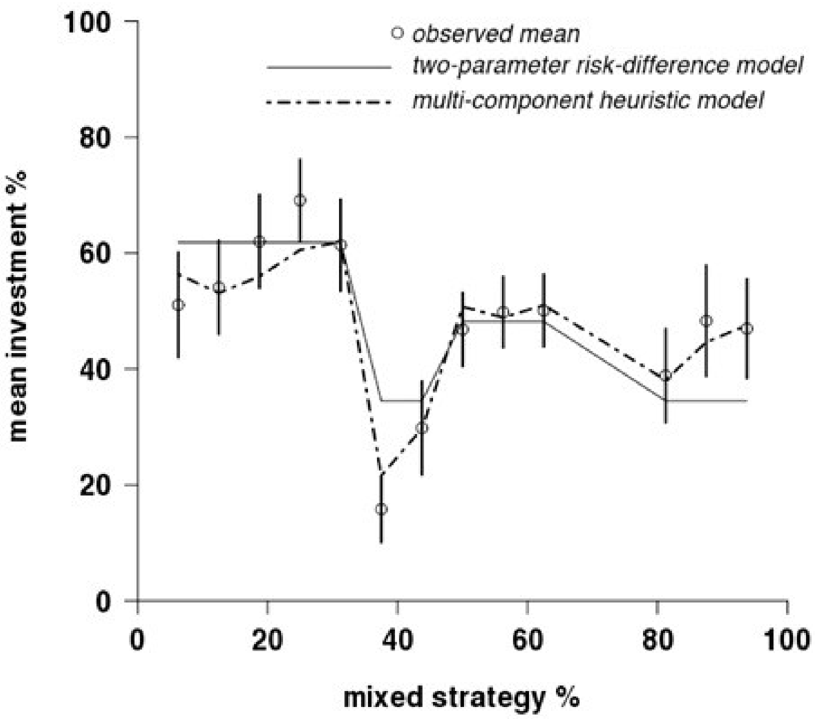

FIGURE 5. OBSERVED MEAN INVESTMENT PROBABILITY AS A FUNCTION OF MIXED STRATEGY EQUILIBRIA (ERROR BAR = ONE ESTIMATED STANDARD ERROR)

Figure 5 shows the value of the mixed strategy equilibrium on the abscissa. The ordinate is the observed mean investment percentage for the subset of trials with a given value of the mixed strategy equilibrium, i.e., a given value of opponent's cost. Given the values chosen for our experiment the mixed strategy equilibrium takes 13 different values.

The strict zero-parameter model for hypothesis 1 ($y_{it} = m_{it} + \varepsilon_{it}$) would predict that the observed investment means fall on a 45° line through the origin of Figure 5. This is obviously false, and in fact, the variation is severely non-monotonic. The detailed non-monotonicity is approximately explained by cost differences, as shown by the solid line, which gives the fit of the 2-parameter model for risk dominance $(y_{it} = \alpha + \beta r_{\Delta t} + \varepsilon_{it})$. There are exactly three levels of cost-difference corresponding to the 13 levels of opponent's cost: a positive difference (+2,250 Talers), an equal but opposite negative difference (-2,250 Talers), and a zero difference arising from the situation where the same opponent's cost is paired in the design with both a positive and a negative cost difference (see Table 5 in Appendix I). These three levels, adjusted by the linear fit of a 2-parameter r_Δ model are visible in the flat portions of the solid curve in Figure 5. A slightly better fit can be obtained using the multi-component version of the r_Δ model but this improvement would barely be noticeable in Figure 5, so we have omitted that fit for the sake of readability. A distinctly better fit is obtained when different coefficients are used for own and opponent's cost (dashed line in Figure 5). Here, we use the multi-component general model $(y_{it} = \alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it})$, with 132 intercept and slope parameters; but the fit of a 3-parameter model, omitting the components of individual variation, is only just noticeably worse in Figure 5.

Figure 5 cannot substitute for the components-of-variance analyses shown in the three diagrams above (Figures 2-4), since there is little sensitivity to individual variation, but it does show clearly the qualitative differences among the three classes of explanatory models. Models based on opponent's cost alone, as realized by the mixed strategy equilibrium, are grossly wrong; models based on risk dominance, which here reduces to cost difference, are much better but fail in detail, precisely because the weighting on a player's own cost is roughly double that on the opponent's cost. The heuristic model based on linear reactions to own and opponents cost performs better.

To help understand the lack of sensitivity to individual variation in this way of comparing models, note that Figure 5 would not make any distinction between a 1-parameter model (α in Figure 2) versus the 44-parameter α_i, the best model in Figure 2. Because all 44 individuals are averaged in each of the 13 means in Figure 5, and the mean of the estimated α_i is exactly the estimate of the single parameter α, these two models would just fit the same horizontal line to the data in Figure 5. For the more complex models related to hypotheses 2 and hypothesis 3, there is some sensitivity to individual variation in this comparison method, but not enough for purposes of model selection.

2.4.6 Generalizability

To test the generalizability of these results, we compared coordination behavior of students and entrepreneurs. For model 2, we calculated the average effect of risk dominance (mean of the coefficients β_i in model 2) for each group. A 95% confidence interval for the difference between mean risk-dominance slopes of students and entrepreneurs is (-0.0028, +0.0077). While we cannot conclude that students and entrepreneurs differ in average weight placed on risk dominance (in the framework of hypothesis 2), the difference between the two groups could be very large – the sample size of entrepreneurs is small and the variability within both groups is considerable.

For model 3, we calculated the average reactions to own cost (mean value of coefficient β_i in model 3) and the average reaction to counterparts cost (mean value of coefficient γ_i in model 3). While own cost had a negative effect on investment probabilities for both students and entrepreneurs this effect is stronger for students (-0.0093) compared to entrepreneurs (-0.0073). A 95% confidence interval for the difference between mean own cost slopes of students and entrepreneurs is (-0.0079, +0.0039). The independent sample t-test for the between group comparison of the coefficient β_i gives a $p > 0.05$. Thus, we cannot reject the null hypothesis, that coefficients for own cost are equal for entrepreneurs and students. Similarly, the average reaction to increases in counterpart's cost (mean value of coefficient γ_i in model 3) is stronger for students (0.0047) than for entrepreneurs (0.0021). A 95% confidence interval for the difference between the mean of opponents' cost slopes of students and entrepreneurs is (-0.0030, +0.0082). The sample t-test for the between-group comparison of coefficient γ_i gives $p > 0.05$. Hence, we can neither reject the null hypothesis that coefficients for counterpart's cost are equal for both groups. As in the case of hypothesis 2, these differences between students and entrepreneurs are accompanied by wide confidence intervals, so we remain unsure whether or not the differences are negligible or substantial.

2.5 Discussion

2.5.1 Mixed strategy equilibria, risk dominance and decision heuristics

Given that the analyzed coordination game is a one-shot game, the poor performance of the mixed strategy equilibrium in explaining behavior is not surprising (e.g., Heinemann et al. 2009). However, as the mixed strategy equilibrium is a central concept in the literature on classic coordination games, we consider it important to test this concept for dual uncertainty coordination. Having allowed people to explicitly state mixed strategies, we are confident that the poor performance of the mixed strategy equilibrium in our dual-uncertainty game is robust.

Risk dominance and the suggested decision heuristic both explain coordination behavior under dual-uncertainty well. The predictions of both concepts point into the same direction: predicting a negative influence of increases in own cost and a positive influence of increases in opponents cost. Even though similar in directional predictions, the heuristic model performed better in our statistical analysis. If we would have compared the heuristic model with a strict 0-parameter model for risk dominance the heuristic model would have performed even better. This result is driven by two aspects: (a) The heuristic model has 132 parameters while the risk dominance model has 88 and is thus per se less sensitive to individual variation (please note that a strict risk dominance model would have no free parameter); (b) More importantly, the risk dominance model fails in detail precisely because the weighting on a player's own cost is roughly double that on the opponent's cost. This is a strong argument in favor of the suggested heuristic model. Table 3 provides an overview of the sign of the reactions to own and opponents cost (parameters β and γ, respectively).

TABLE 3. OVERVIEW REACTIONS TO OWN AND OPPONENTS COST IN MODEL 3 (BASED ON 44 SUBJECTS)

		Reaction to own cost β: negative	Reaction to own cost β: positive
Reaction to opponent's cost γ	positive	26	3
	negative	12	3

Across 44 subjects, 26 followed the predicted pattern exactly (negative reaction to own cost and positive reactions to opponent's cost), while 12 exhibit negative reactions to increases in own and opponent's cost. Only a small fraction of participants reacted positively to increases in own cost. Moreover, the absolute magnitude of reaction to own cost is larger than that of reactions to opponent's cost. Thus, expectations are met fairly well, although there is a strong minority that reacts negatively to increases in opponent's cost. For this group the assumption of social projection is implausible.

Including cost values outside the coordination interval to which we restricted our experiment, the proposed heuristic would offer an advantage to the decision maker: For cost values outside this range (see Appendix II, especially Figure 6 therein), the game can have a unique equilibrium in (I, I) when costs are sufficiently low for both players or a unique equilibrium in (N, N) when costs for both are higher than expected payoffs from investing. In practice, with limited analysis and calculation, players might be uncertain whether or not the cost situation they face leads to a coordination problem. The proposed heuristic will lead them in the right direction, no matter which cost range they are in. It is robust against situational changes.

2.5.2 Participants who did not react to changes in cost levels

Some participants were excluded from the regression analysis because they made the same decision in all rounds. From these 11 participants, seven always invested with a 100% probability, one indicated a 50% investment probability in each round, another always indicated a 10% investment probability and two never invested. These decisions can be explained within the concept of the suggested heuristic model while they are not plausible within the concepts of mix strategy play and risk dominance. Within the cost heuristic concept, these responses could be interpreted as mirroring that the variability of own and opponent's cost is too low to cause changes in investment probability of the respective participants. Taking into account both, the results from the model comparison and the behavior of the excluded participants, participants' behavior in the experiment favors the heuristic model stronger.

2.5.3 Asymmetries as coordination device

The result that coordination behavior under dual-uncertainty is better explained by a heuristic that is based on a salient asymmetry (in our game with respect to own cost and opponent's cost) is in line with related studies on classic coordination games where asymmetries play a crucial role (e.g., Cabrales et al. 2000, Leland 2006, Di Guida and Devetag 2011). Coordination problems in real life situations typically involve asymmetries between the different decision makers. It is thus promising to further study the role of asymmetries for coordination behavior under dual-uncertainty. In particular the link between payoff asymmetries and the concept of risk dominance seems to be a fruitful area for further research. Future research should clarify if peoples' tendency to use salient asymmetries as a coordination device could explain why in many situations the risk dominance criterion predicts behavior well in dual uncertainty coordination even though it is unlikely to be actually applied by decision makers as a decision rule.

2.5.4 Generalizability

Testing the generalizability of our results with a sample of entrepreneurs, we cannot conclude that decision patterns of students and entrepreneurs differ. However, as the sample size of entrepreneurs is small and the variability within both groups is considerable the difference between the two groups could be very large. In line with these results Table 4 show coordination outcomes for both groups separately:

TABLE 4. COORDINATION OUTCOMES

STUDENTS

$c_i > c_j$ \ $c_i < c_j$	I (60%)	N (40%)
I (37.8%)	22.7%	15.1%
N (62.2%)	37.3%	24.9%

ENTREPRENEURS

$c_i > c_j$ \ $c_i < c_j$	I (64%)	N (36%)
I (46.5%)	29.8%	16.7%
N (53.5%)	34.2%	19.3%

When own cost was lower than the opponent's cost, the mean investment probability of the student participants was 60percent while the mean investment probability of the entrepreneurs was 64 percent. When own cost was higher than the opponent's cost, the mean investment probability of the students participants was 37.8 percent; entrepreneur's mean investment probability was 46.5 percent in this case. Calculating coordination outcomes for a representative agent leads to the two outcome tables above. Students' coordination behavior would have lead to playing the risk dominant equilibrium in 37.3 percent of the cases, while the risk-dominated equilibrium would have been played only in 15.1percent of the cases. For the entrepreneurs' sample we a very find a similar pattern: the entrepreneurs would have coordinated on the risk dominant equilibrium in 34.2 percent of the cases. The risk-dominated equilibrium would have been played in 16.7 percent of the cases. Furthermore, we entrepreneurs exhibit a slightly stronger tendency towards investing than the students. This is mirrored in reaching the off-equilibrium strategy combination (I,I) more often than the students.

2.5.5 Other concepts

In this paper we focused on mixed strategy equilibria, risk dominance and a decision heuristic based on cost and social projection. Another concept that could be considered is the concept of Lebesque stability sets. For 2x2 games the Lebesque stability set predictions the same outcome as the risk dominance criterion. Hence, for the considered game we can conclude that the Lebesque stability measure would have describes behavior well. Future research might investigate the relationship between the Lebesque stability measure and decision heuristics in coordination under dual uncertainty.

2.6 Conclusions and future research

We conducted experiments on coordination behavior under strategic uncertainty and exogenous payoff uncertainty. Results show that while the explanatory power of the risk dominance criterion is relatively high, a decision heuristic based on cost and social projection explains coordination behavior under dual-uncertainty better. This has implications for future research: the risk dominance criterion might predict behavior relatively well although decisions are actually driven by other factors. If one studies the impact of risk dominance without testing it *against* other concepts, one might find that risk dominance is important for understanding behavior in a coordination game. What individuals instead might have done, e.g., orienting on asymmetries and descriptive features and heuristically choose an action, might be hidden by the mere fact that this alternative was not tested against risk dominance. This suggests that studies on equilibrium selection should also test alternative concepts. The methodology provided in this paper shows how this could be done. By identifying what actually drives behavior, future research might help to make better predictions for coordination behavior under dual-uncertainty, and to understand *why* risk dominance makes good predictions. This requires analyzing the link between those features that make an equilibrium point risk dominant and the features that shape potential heuristics, such as i.e., payoff asymmetry.

References

Allport, F.H., 1924. *Social psychology*. Cambridge. MA: Riverside Press.

Anderhub, V., Engelmann, D., and Güth, W., 2002. "An experimental study of the repeated trust game with incomplete information". *Journal of Economic Behavior and Organization*, 48, 197-216.

Baron, R.A.,1998. "Cognitive Mechanisms in entrepreneurship: Why and when entrepreneurs think differently than other people". *Journal of Business Venturing*, 13, 275-294.

Biel, A., and Gärling, T., 1995. "The role of uncertainty in resource dilemmas". *Journal of Environmental Psychology*, 15, 221-233.

Brandts, J., and Yao, L., 2010. "Ambiguous information and market entry: an experimental study". MPRA working paper 25276.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1990. "Resource dilemmas with environmental uncertainty and asymmetric players". *European Journal of Social Psychology*, 20, 475-487.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1992. "Simultaneous vs. Sequential Requests in Resource Dilemmas with incomplete information". *Acta Psychologica*, 80, 287-310.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1995a. "Common pool resource dilemmas under uncertainty: Qualitative tests of equilibrium solutions". *Games and Economic Behavior*, 10, 171-201.

Budescu, D.V., Rapoport, A., and Suleiman, R., 1995b. "Positional order and group size effects in resource dilemmas with uncertain resources". *Organizational Behavior and Human Decision Processes*, 61, 225-238.

Busenitz, L.W., and Barney, J.B., 1997. "Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making". *Journal of Business Venturing*, 12, 9-30.

Cabrales, A., García-Fontes, W., and Motta, M., 2000. "Risk dominance selects the leader: an experimental analysis". *International Journal of Industrial Organization*, 18, 137-162.

Cabrales, A., Nagel, R., and Armenter, R., 2007. "Equilibrium selection through incomplete information in coordination games: an experimental approach". *Experimental Economics*, 10, 221-234.

Cachon, G.F., and Camerer, C.F., 1996. "Loss-avoidance and forward induction in experimental coordination games". *The Quarterly Journal of Economics*, 111, 165-194.

Camerer, C.F., 2003. *Behavioral Game Theory – Experiments in Strategic Interaction*. Russell Sage Foundation: Princeton University Press, New York.

Cooper, A.C., Woo, C.Y., and Dunkelberg, W.C., 1988. "Entrepreneurs' perceived chances for success". *Journal of Business Venturing*, 3, 97-108.

Cooper, R., DeJong, D., Forsythe, R., and Ross, T., 1990. "Selection criteria in coordination games: some experimental results". *American Economic Review,* 80, 218-233.

Crawford, V.P., 1991. "An 'evolutionary' interpretation of Van Huyck, Battalio, and Beil's experimental results on coordination". *Games and Economic Behavior*, 3, 25-59.

De Vries, S. and Wilke, H.A.M., 1995. "An advisor in resource management situations. Configural weighing of recommendations". *Journal of Economic Psychology*, 16, 115-135.

De Vries, S., and Wilke, H.A.M., 1992. "Constrained egoism and resource management under uncertainty". In W.B.G. Liebrand and D. M. Messick (Eds.), *Social dilemmas: Theoretical issues and research findings*, 81-100). Oxford, UK: Pergamon Press.

Di Guida, S. and Devetag, G., 2011. "Feature-based Choice and Similarity in Normal-form Games: An Experimental Study". INRA working paper.

Festinger, L., 1954. "A theory of social comparison process". *Human Relations*, 7, 117-140.

Février, P., and Linnemer, L., 2006. "Equilibrium selection: Payoff or risk dominance? The case of the weakest link". *Journal of Economic Behavior & Organization*, 60, 164-181.

Fischbacher, U., 2007. "Z-Tree: Zurich Toolbox for Ready-made Economic Experiments". *Experimental Economics*, 10, 171-178.

Gangadharan, L. and Nemes, V., 2009. "Experimental Analysis of Risk and Uncertainty in Provisioning Private and Public Goods". *Economic Inquiry,* 47, 146-164.

Gigerenzer, G., Todd, P.M., and the ABC Research Group, 1999. *Simple heuristics that make us smart*. New York: Oxford University Press.

Gong, M., Baron, J., and Kunreuther, H., 2009. "Group cooperation under uncertainty". *Journal of Risk and Uncertainty*, 39, 251-270.

Harsanyi, J.C., and Selten, R., 1988. *A general theory of equilibrium selection in games*. Cambridge MA: The MIT Press.

Heal, G., and Kunreuther, H., 2005. "You can only die once: Interdependent Security in an Uncertain World". in Richardson, H.W., Gordon, P. and Morre II, J.E. (Eds.) *The Economic Impacts of Terrorist Attacks*, Edward Elgar, Cheltenham.

Heinemann, F., Nagel, R., and Ockenfels, P., 2009. "Measuring Strategic Uncertainty in Coordination Games". *The Review of Economic Studies*, 76, 181-221.

Holt, C.A., & Laury, S.K., 2002. "Risk Aversion and Incentive Effects". *American Economic Review*, 92, 1644-1655.

Kahneman, D., Slovic, P., and Tversky, A., 1982. *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Karelaia, N., and Hogarth, R., 2010. "The attraction of uncertainty: Interactions between skill and levels of uncertainty in market-entry games". *Journal of Risk and Uncertainty*, 41, 141-166.

Krueger, J., 2000. "The projective perception of the social world: a building block of social comparison processes". In M.J. Suls and L. Wheeler (Eds.), *Handbook of social comparison: theory and research*, 323-351, New York: Plenum/Kluwer.

Krueger, J., 2007. "From social projection to social behavior". *European Review of Social Psychology,* 18, 1-35.

Leland, J.W., 2006. "Equilibrium Selection, Similarity Judgments and the "Nothing to Gain/Nothing to Lose" Effect". CEEL Working paper 06_04.

Levati, V., Morone, A., and Fiore, A., 2009. "Voluntary contributions with imperfect information: An experimental study". *Public Choice*, 138, 199-216.

McCabe, K. A., Mukherji, A. and Runkle, D., 2000. "An Experimental Study of Information and Mixed-Strategy Play in the Three- Person Matching-Pennies Game". *Economic Theory*, 15, 421-62.

Messick, D.M., Allison, S.T., and Samuelson, C.D., 1988. "Framing and communication effects on group members' responses to environmental and social uncertainty". In S. Maital (Ed.), *Applied Behavioural Economics*, 2, 677-700. New York: New York University Press.

Metha, J., Starmer, C., and Sugden, R., 1994. "The nature of salience: an experimental investigation of pure coordination games". *American Economic Review*, 84, 658-673.

Mookherjee, D. and Sopher, B., 1994. "Learning Behavior in an Experimental Matching Pennies Game". *Games and Economic Behavior*, 7, 62-91.

O'Neill, B., 1987. "Nonmetric Test of the Minimax Theory of Two-Person Zerosum Games". *Proceedings of the National Academy of Sciences*, 84, 2106-2109.

Ochs, J., 1995. "Games with Unique, Mixed Strategy Equilibria: An Experimental Study". *Games and Economic Behavior*, 10*,* 202-217.

Orive, R., 1988. "Social projection and comparision of opinions". *Journal of Personality and Social Psychology*, 54, 953-964.

Payne, J.W., Bettman, J.R., and Johnson, E.J., 1993. *The Adaptive Decision Maker*. Cambridge: Cambridge University Press.

Rapoport, A. and Au, W.T., 2001. "Bonus and penalty in common pool resource dilemmas under uncertainty". *Organizational Behavior and Human Decision Processes*, 85, 135-165.

Rutte, C.G., Wilke, H.A.M., and Messick, D.M., 1987. "Scarcity or abundance caused by people or the environment as determinants of behavior in the resource dilemma". *Journal of Experimental Social Psychology*, 23, 208-216.

Schade, C., Schroeder, A., and Krause, K., 2010. "Coordination after gains and losses: Is prospect theory's value function predictive for games?" *Journal of Mathematical Psychology*, 54*,* 426-445.

Schmidt, D., Shupp, R., Walker, J.M., and Ostrom, E., 2003. "Playing safe in coordination games: The roles of risk dominance, payoff dominance, and history of play". *Games and Economic Behavior*, 42, 281-299.

Straub, P.G., 1995. "Risk dominance and coordination failures in static games". *The Quarterly Review of Economics and Finance*, **35,** 339-363.

Suleiman, R., and Rapoport, A., 1988. "Environmental and Social Uncertainty in Single-Trial Resource Dilemmas". *Acta Psychologica*, 68, 99-112.

Sundali, J.A., Rapoport, A., and Seale, D.A., 1995. "Coordination in Market Entry Games with Symmetric Players". *Organizational Behavior and Human Decision Processes*, 64, 203-218.

Thomas, J., and McFadyen, R., 1995. "The confidence heuristic: A game-theoretic analysis". *Journal of Economic Psychology*, 16, 97-113.

Tversky, A., and Kahneman, D., 1974. "Judgment under uncertainty: Heuristics and biases". *Science*, 185, 1124-1131.

Van Huyck J., Battalio R., and Beil, R., 1990. "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure". *American Economic Review*, 80, 234-307.

Wit, A. and Wilke, H.A.M., 1998. “Public good provision under environmental and social uncertainty”. *European Journal of Social Psychology,* 28, 249-256.

Appendices

Appendix I: Tables

TABLE 5. COST COMBINATIONS USED IN EXPERIMENT

COST LEVELS PLAYER I	COST LEVELS PLAYER J
23,250	25,500
23,700	25,950
25,500	23,250
25,500	27,750
25,950	23,700
25,950	28,200
26,400	24,150
26,400	28,650
27,300	29,550
27,750	25,500
28,650	26,400
29,100	26,850
29,550	27,300

TABLE 6. OVERVIEW F-TESTS

MODEL	UNRESTRICTED MODEL	RESTRICTED MODEL	F-TEST
Model 1	$y_{it} = \alpha_i + \beta_i m_{it} + \varepsilon_{it}$	$y_{it} = \alpha_i + \beta m_{it} + \varepsilon_{it}$	F(43,264) = 1.183 p-v=0.214
		$y_{it} = \alpha + \beta m_{it} + \varepsilon_{it}$	F(43,307) = 2.772 p-v=0.000
Model 2	$y_{it} = \alpha_i + \beta_i r_{\Delta t} + \varepsilon_{it}$	$y_{it} = \alpha_i + \beta r_{\Delta t} + \varepsilon_{it}$	F(43,264) = 2.132 p-v=0.000
		$y_{it} = \alpha + \beta r_{\Delta t} + \varepsilon_{it}$	F(43,307) = 3.160 p-v=0.000
Model 3	$y_{it} = \alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$	$y_{it} = \alpha_i + \beta c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$	F(43,220) = 1.746 p-v=0.005
		$y_{it} = \alpha_i + \beta_i c_{it} + \gamma c_{jt} + \varepsilon_{it}$	F(43,220) = 1.958 p-v=0.001
		$y_{it} = \alpha_i + \beta c_{it} + \gamma c_{jt} + \varepsilon_{it}$	F(43,263) = 1.522 p-v=0.026
		$y_{it} = \alpha + \beta c_{it} + \gamma c_{jt} + \varepsilon_{it}$	F(43,306) = 1.522 p-v=0.000

TABLE 7. R-SQUARED AND R-SQUARED ADJUSTED

MODELS	SUB-MODELS	R SQUARED	R SQUARED ADJUSTED
Model 1	$y_{it} = \alpha_i + \beta_i m_{it} + \varepsilon_{it}$	0.752	0.669
	$y_{it} = \alpha_i + \beta m_{it} + \varepsilon_{it}$	0.704	0.660
	$y_{it} = \alpha + \beta m_{it} + \varepsilon_{it}$	0.006	0.004
Model 2	$y_{it} = \alpha_i + \beta_i r_{\Delta t} + \varepsilon_{it}$	0.811	0.748
	$y_{it} = \alpha_i + \beta r_{\Delta t} + \varepsilon_{it}$	0.746	0.708
	$y_{it} = \alpha + \beta r_{\Delta t} + \varepsilon_{it}$	0.114	0.111
Model 3	$y_{it} = \alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$	0.855	0.768
	$y_{it} = \alpha_i + \beta c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$	0.805	0.740
	$y_{it} = \alpha_i + \beta_i c_{it} + \gamma c_{jt} + \varepsilon_{it}$	0.799	0.732
	$y_{it} = \alpha_i + \beta c_{it} + \gamma c_{jt} + \varepsilon_{it}$	0.757	0.720
	$y_{it} = \alpha + \beta c_{it} + \gamma c_{jt} + \varepsilon_{it}$	0.141	0.136

Appendix II: Equilibrium analysis for R&D investment game

The expected return on the research and development investment and therewith the incentive to invest decreases with the number of other players investing. Consequently the incentive to invest is highest when no other entrepreneur invests. Equilibrium analysis for pure strategies shows that:

If costs for both players are sufficiently low, i.e., $c_i < (1 - q_i p_j) p_i G$ and $c_j < (1 - q_j p_i) p_j G$, (I, I) is the only pure Nash equilibrium and both players should invest into R&D even though there is an option to copy the innovation from the opponent. Since the success of the other entrepreneur's investment is uncertain and since costs for own research and development activities are sufficiently low, the expected return from one's own investment exceeds its costs $(c_i < p_i G)$ and the incentive to invest $(p_i G - c_i)$ exceeds the free riding incentive $(q_i p_j G)$. If costs for both players are sufficiently high which is the case when they exceed expected return from the investment, i.e., $c_i > p_i G$ and $c_j > p_j G$ then (N, N) is the only pure Nash equilibrium and none of the players should invest. With this parameter constellation the interdependence between the players' decisions losses its crucial influence on the decision of each individual player because the R&D project is not attractive enough to invest the necessary resources no matter what the other player is doing.

If $c_i < p_i G$ and $c_j > (1 - q_j p_i) p_j G$ then (I, N) is a Nash equilibrium, meaning that player *i* should invest because his investment costs are lower than the expected returns from the investment, hence investing is a dominant strategy for her. Player *j* should try to copy the new technology, because his costs are higher than the expected returns from relying on entrepreneur *i*'s investment and trying to copy the innovation. Thus, his expected payoffs are higher when he decides not to invest but to try copying as when he decides to invest himself. The same holds contrariwise: If $c_i > (1 - q_i p_j) p_i G$ and $c_j < p_j G$ then (N,I) is a Nash equilibrium. For $(1 - q_i p_j) p_i G < c_i < p_i G$ and $(1 - q_j p_i) p_j G < c_j < p_j G$ (I,N) and (N,I) are both Nash equilibria.

The equilibrium intervals for the 2-player scenario are depicted as a function of c_i and c_j in Figure 6:

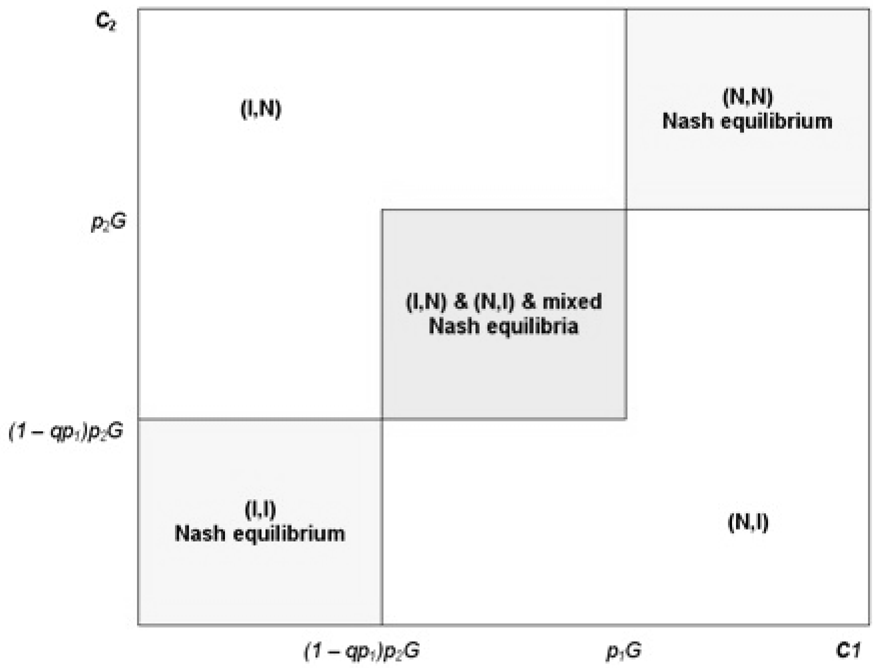

FIGURE 6. EQUILIBRIUM PREDICTIONS AS A FUNCTION OF C_1 AND C_2

Appendix III: Payoff dominance criterion

In order to be strictly payoff dominant, the respective equilibrium must yield higher payoffs for all players than any other equilibrium. Weak payoff dominance requires that none of the players yields a lower payoff than in any other equilibrium.

Thus, in order for *(I,N)* to be payoff dominant, the payoffs of both players need to be higher than their respective payoffs in (N,I). This is the case when: $Y + p_i G - c_i > Y + q_i p_j G$ and $Y + p_j G - c_j < Y + q_j p_i G$ with $p_i = p_j$ and $q_i = q_j$ $\Rightarrow$ $c_i < pG(1-q)$ and $c_j > pG(1-q)$. But if this condition holds, (N,I) is not an equilibrium and there exists a single unique pure equilibrium in (I,N), as $pG(1-q) <$ pG and $pG(1-q) >$ $pG(1-qp)$ for any $q < 1$ and $p < 1$. As the game structure is symmetric, this also accounts for the reverse case. Hence, for $p_i = p_j$ and $q_i = q_j$ none of the two equilibria is payoff dominant

Appendix IV: Model nesting

Model 1: $y_{it} = \alpha_i + \beta_i m_{it} + \varepsilon_{it}$ where $m_{it} = \dfrac{pG - c_{jt}}{p^2 qG}$

Model 2: $y_{it} = \alpha_i + \beta_i r_{\Delta t} + \varepsilon_{it}$

Model 3: $y_{it} = \alpha_i + \beta_i c_{it} + \gamma_i c_{jt} + \varepsilon_{it}$

Model 1 and model 2 are nested in model 3 under the following conditions:

Model 2 is nested in model 3 under the restriction: $\beta_i^{M3} = -\gamma_i^{M3}$

Model 1 is nested in model 3 under the restriction: $\beta_i^{M3} = 0$

Appendix V: Instructions

Welcome to our experiment!

The following experiment investigates your decision behavior. It consists of two parts.

In the first part of the experiment, you will play 9 rounds of an investment game with the same, randomly chosen, anonymous person. Your payoff from this game depends on your own decisions but also on the behavior of your counterpart. Your counterpart has the same information that you have.

At the end of the experiment you will be given an overview of the results of each of the 9 rounds that you played. One of these rounds will be randomly chosen to determine your payoff from the game. Between rounds you will not receive any information about your counterpart's decision.

The experiment uses the currency 'Talers'. For 10,000 'Talers' achieved in the chosen round you will be paid 1 € in cash at the end of the experiment.

In the second part of the experiment you will be asked to decide between lotteries. Also for this part of the experiment, you will be paid in accordance to your decisions. After you have completed the first part of the experiment, you will receive further instructions for the second part.

At the end of the experiment we are going to ask you some additional questions concerning your person.

Good Luck!

General rules

For this experiment it is essential that you do not communicate with the other participants.

In each round, the computer will wait until all participants have made their decisions. Please remain absolutely quiet should any waiting pauses emerge.

The instructions for this experiment will be displayed on the computer screen step by step. They are also distributed to you as hard copies in case you want to go back to parts you might have forgotten. You are free to use a calculator. You will find a calculator symbol in the lower corner on the right hand side of your display. Please note: The calculator does not automatically perform according to the order of operation rules, i.e. multiplication has precedence over addition.

Please raise your hand in case you have any questions. The experimenter will come to you and answer your questions. Please remain absolutely quiet meanwhile.

Part one: Research and development investments

Please, imagine the following situation: You are the owner of a high-tech enterprise and you have the opportunity to invest into a new R&D project. Your endowment is 100,000 'Talers'. You can either invest the 'Talers' into the project or not. The innovation you could develop in this project generates an additional profit of 100,000 'Taler' if your research project turns out to be successful.

The success rate of research projects in your industry and for your enterprise is 30 percent, i.e. three out of ten research projects are successful. However, you might can still be able to copy the innovation from your competitor in case your effort turns out to be not successful or in case you did not invest in the project in the first place. Copying will be successful in 80 percent of the cases. It is costless and happens automatically, if you did not generate the innovation but you counterpart has invested into the project and was successful. Your counterpart will not experience losses if you copy his innovation.

In the following nine rounds, you will be confronted with different levels of investment costs – for you as well as for your counterpart. Each round you have to decide on whether you would like to invest or not, given the respective scenarios.

Please turn to the next page in order to get an explanation of how to submit your investment decision.

How to submit your investment decision:

Your investment decision will be determined with the help of a bingo cage. You will fill this bingo cage with balls. In the end, there will always be 100 balls inside the cage. There are black and white balls, whereas any mixture of both colors is possible. You will determine the content by indicating the amount of white balls you want to fill the cage with. Afterwards, the bingo cage will be filled with black balls until the number of 100 balls is reached.

Now, one ball will be randomly drawn out of the cage by chance. In case this ball is white, your investment will be conducted. In case a black ball is drawn, the investment will not happen.

How to submit your investment decision (cont.):

With deciding on putting more white balls into the bingo cage the probability of drawing a white ball, i.e. conducting the investment, increases. However, less white balls in the cage imply a lower probability of drawing a white ball and thus no investment.

Hence, if you decide to fill the bingo cage with 100 white balls you will definitely invest since a white ball will always be drawn. On the other hand, if you decide to put no white ball inside the cage you will never invest. We will ask for your investment decision in each round by determining the number of white balls you wish to provide the bingo cage with.

The question will look like the following:

How many white balls do you want to put into the bingo cage? (0 to 100)?

Note that you can only point out numbers from 0 to 100 since there always have to be 100 balls in the cage.

You will now start with the investment game.

Please, make sure to make the best possible decision in each round since any of the rounds played might be relevant for your payoff.

R&D investment

Your endowment and the endowment of your counterpart is 100,000 ‘Talers’, each.

If you invest, you will be successful with a probability of 30 percent and gain another 100,000 ‘Talers’ because of the innovation you generated. Your investment costs amount up to 27,300 ‘Talers’.

In case your counterpart invests, he will be successful with a probability of 30 percent and gain 100,000 ‘Talers’ because of the innovation he generated. His investment costs add up to 29,550 ‘Talers’.

If you or your counterpart do not invest or turn out to be not successful, one can try to copy the innovation of the counterpart, given the other has invested and was successful. Copying happens automatically and is costless. A 100,000-Taler-gain will be generated with a success probability of 80 percent.

None of the players can observe the other’s decision. Your counterpart received the same information as you.

Please provide your investment decision now by determining the number of white balls you choose to be put into the bingo cage. In case a white ball is drawn the investment will be conducted.

How many white balls do you want to put into the bingo cage? (0 to 100)?

3. Market entry decisions after gains and losses

Article **2:**

Market entry decisions after gains and losses:

Gender matters, being an entrepreneur does not

Christian Schade and Sabrina Boewe

We study whether gender differences that have been found in a market entry experiment with pre-game gain and loss experiences also hold for entrepreneurs. As male and female entrepreneurs self-select into a highly risky and competitive field our hypothesis is that gender differences should be smaller among entrepreneurs. While our findings confirm gender differences in entry behavior, contrary to our expectations, this gender difference maintained for male and female entrepreneurs and also for women playing against other women. Entry behavior of most male and female participants is consistent with the assumption of social projection.

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3.1 Introduction

Behavioral economics has documented significant gender differences in several domains of decision making that are related to occupational choice. Most prominently gender specific attitudes towards risk taking and competition have been discussed to explain labor market differences (e.g., Cramer et al. 2002, Bonin et al. 2007, Sapienza et. al. 2009, Niederle and Vesterlund 2011). This raises the question whether women who have self-selected into a risky and competitive occupation, i.e., entrepreneurship, act more similarly to their male counterparts. We thus experimentally investigate the decision behavior of female entrepreneurs as compared to that of male entrepreneurs as well as that of female and male non-entrepreneurs, and examine whether the behavioral gender gap is smaller with entrepreneurs than with non-entrepreneurs.

For our experiment we used the framework of the market entry game (Selten and Güth 1982; Kahneman 1988) which has been used to study decision making related to entrepreneurship (e.g., Camerer and Lovallo 1999, Elston et al. 2006, Moore et al. 2007, Brandts and Yao 2010). In the market entry game, several players simultaneously decide on entering or not entering an experimental market with a limited capacity. Payoffs from entering decrease with the number of entrants. If too many players enter, all entrants suffer a loss. Players cannot observe, communicate, and collude with their opponents. When making their entry decision, they face strategic uncertainty about the choices of the other players. Studying coordination behavior in this game, breaking the symmetry this game otherwise implies, and making the decision situation more realistic by randomly inducing pre-game gain and loss experiences, Schade et al. (2010) found significant gender differences. Giving participants the possibility to use their own and their opponents' prior experiences as a coordination device, they found that entry patterns of men and women differed significantly. While men entered clearly more after a loss than after a gain experience, women did not react as much to own gains and losses. Also the reactions to the opponents' gain and loss experiences differed between men and women. Men entered systematically more when playing against opponents with a gain experience and less when playing against opponents with a loss experience. Women's reactions were less clear. They played mixed strategies much more often than men and entered on average more when playing against opponents with a loss experience than when playing against opponents with a gain experience. Schade et al. (2010) suggest that these findings can be explained by men using social projection more often than women; i.e., that men more often than women presume their counterparts to behave in the same way as they would behave (Allport 1924, Festinger 1954, Krueger 2000). Also, women seem to interpret the initial random lottery outcomes used to manipulate prior experiences as a signal for the players' abilities to compete. We expect the behavioral gender difference to be smaller for entrepreneurs where women self-select into an occupation which is risky, competitive, and still widely dominated by men. Our hypothesis is that due to self-selection and learning to compete in a male dominated field, female entrepreneurs should exhibit decision patterns more similar to their male counterparts than women in general.

Our experiment partially replicates the study by Schade et al. (2010) with male and female entrepreneurs and male and female non-entrepreneurs. We ran mixed-sex sessions and sessions with only female participants to allow a robustness check of our results as previous research found behavioral differences between mixed- and single-sex sessions, especially with females (Gneezy at al. 2003). We find that while gender matters for behavior, being an entrepreneur does not. Contrary to our expectations, we find that the market entry decisions of female entrepreneurs are not more similar to those of male entrepreneurs than the entry decisions of men and women in general. Women entered less than men independent of whether they were entrepreneurs or not. Risk propensity matters but was not correlated with either gender or group. The gender composition within a session did not have a significant effect on women's behavior although reaction patterns to opponents' gain and loss experiences tend to be less structured in sessions with only female participants. Our results further show that participants enter more after a loss than after a gain and that most participants – males and females – enter less when playing against opponents' with a loss experience than when playing against two opponents with a gain experience. These findings largely confirm the results by Schade et al. (2010). Differences in results on reactions to opponents' experiences are discussed in the discussion section.

Our unexpected and quite surprising core result that the behavioral gap between male and female entrepreneurs is not smaller than between male and female non-entrepreneurs is discussed within the context of research on female entrepreneurship.

The next section gives a brief summary of the main results on gender differences in decision making related to entrepreneurial activity and our hypotheses. In section three the experimental design and procedure is described. The analysis and results are presented in section four, followed by the discussion in section five. Section six contains the conclusion.

3.2 Gender differences in decision making and entrepreneurial activity

Previous research has shown that in most domains women take fewer risks than men (Hudgens and Fatkin 1985, Levin et al. 1988, Sexton and Bowman-Upton 1990, Johnson and Powell 1994, Powell and Ansic 1997, Eckel and Grossman 2002, Weber et al. 2002, Johnson et al. 2004, Harris et al. 2006). In a meta-analysis of 150 risk experiments on gender differences Byrnes et al. (1999) conclude that the literature clearly indicates that male participants are more likely to take risks than female participants (p. 377). They also show that the gender difference in risk taking depends on the situation that was considered. Weber et al. (2002) and Johnson et al. (2004) investigated gender differences in risk taking across different content domains. They also found males to be less risk-averse and more likely to engage in risky activities in all of the studied domains – but one: social decision making. Harris et al. (2006) confirm this result.

Men and women have also been found to differ in tournament performance and in their propensity to participate in tournaments (Gneezy et al. 2003, Niederle and Vesterlund 2007, Niederle and Versterlund 2011). While men's performance significantly increased with tournament incentives, women's performance did not increase. The gender gap in performance was larger in mixed gender tournaments than in single-sex tournaments. When participants were paid according to piece rates, no gender gap was found. Niederle and Vesterlund (2007) examined, whether men and women with the same ability differ in their selection into competitive environments.

They found a gender gap in tournament entry, which cannot be explained by performance. Factors such as risk and feedback aversion play a negligible role. Instead the tournament entry gap is driven by men being more overconfident and by gender differences in preferences for performing in a competition. "The result is that women shy away from competition and men embrace it." (Niederle and Vesterlund 2007, p. 1067).

Aspects of risk aversion, competitiveness, and confidence might also underlie the lower rates of women in entrepreneurial activities. In most Western countries, entrepreneurship is still dominated by men while women decide for an entrepreneurial career less often (Reynolds et al. 2001, Blanchflower 2004, Minniti et al. 2004, Allen et. al 2007, Bosma et al. 2009). Cramer et al. (2002) find support for the supposedly negative effect of risk aversion on entrepreneurship selection; however, they do not derive a conclusion concerning the causality of this relationship. Koellinger et al. (2007, 2010) find that women exhibit a lower confidence in own entrepreneurial skills. Those women that did decide for an entrepreneurial activity self-selected into a competitive and still widely male-dominated field. Studying gender differences in a market entry game with entrepreneurs and non-entrepreneurs allows analyzing in how far self-selection and learning to survive in a competitive environment might reduce gender differences in decision making. Based on the above findings we test the following hypothesis:

HYPOTHESIS 1: Men enter the experimental market more often than women.

HYPOTHESIS 2: Entrepreneurs enter the experimental market more often than non-entrepreneurs.

HYPOTHESIS 3: The gender gap in entry decisions is smaller between male and female entrepreneurs than between male and female non-entrepreneurs.

Based on previous results by Schade et al. (2010) we test the influence of own and opponents' pre-game gain or loss experiences on entry behavior:

HYPOTHESIS 4: People enter more after a loss than after a gain.

HYPOTHESIS 5: People enter more playing against opponents with a gain experience than against opponents with a loss experience.

3.3 Experiment

Building on the experimental design by Schade et al. (2010) we used a simultaneous market entry game (Selten and Güth 1982, Kahneman 1988) and induced random pre-game gain and loss experiences. Based on the outcome of a draw from a bingo cage, each participant either made a gain or a loss prior to the market entry game. These gain and loss experiences were common knowledge in the subsequent market entry game while all other individual characteristics were hidden from the participants during the experiment.

3.3.1 Market entry game

In our experiment, three players decided on entering a market with a capacity of two; e.g., only a maximum of two players could enter the market without exceeding the market capacity. If one player entered, his payoff from entering would be one experimental currency unit. If two players entered, their payoff would be zero. If all three entered the market, all would suffer a loss of one experimental currency unit. The payoff function for our decision scenario is given by:

$$u_i(s) = \begin{cases} 0 & \text{if} \quad s_i = 0 \\ r \cdot [2 - N(s)] & \text{if} \quad s_i = 1 \end{cases} \tag{6}$$

where $u_i(s)$ represents player i's payoff given the vector of individual decisions s_i (0 = stay out; 1 = enter) with i = 1,2,3. $N(s)$ is the total number of players who enter the market. The constant r represents the monetary gain or loss players could make by entering. Staying out of the market ($s_i = 0$) leads to a payoff of zero.

3.3.2 Equilibrium predictions

In the considered market entry game, profit maximizing players should prefer to enter the market as long as nobody else enters. They should be indifferent between entering and staying out if one other player enters since their payoff would be zero in both cases. As soon as two other players enter, a profit maximizing player should prefer to stay out in order not to suffer losses. However, in a simultaneous market entry game players make their entry decisions under strategic uncertainty without knowing how their opponents decide. Analyzed from the viewpoint of standard game theory, this game has six pure strategy Nash equilibria: all situations in which the number of entrants equals the market capacity of two and all situations in which there is only one entrant and the others stay out because they are indifferent between entering and staying out. The mixed strategy equilibrium is given by all players entering with a probability of ½ (cf. Rapoport et al. 1998). For equilibrium predictions accounting for reference-dependence of prospect evaluation see Schade et al. (2010) and Schröder (2008).

3.3.3 Experimental design and procedure

All sessions were conducted separately for entrepreneurs and non-entrepreneurs. The entrepreneurs were aware that they were in a session with other entrepreneurs. When the participants arrived in the experimental laboratory, they received a show-up fee. Like all other payoffs, the show-up fee was scaled up by the factor 4.5 for the entrepreneurs in order to account for potential effects of income differentials between the entrepreneurs' sample and the non-entrepreneurs' sample which consisted of students. The show-up fee of 14 Euro (63 Euro for the entrepreneurs) was paid out directly in cash and participants were asked to pocket it before they were seated at separated computer desks. Before the market entry game started, a lottery was conducted. For each participant a random draw from a bingo cage determined whether they won or lost a sum of 6 Euro (27 Euro for the entrepreneurs). Half of the participants in a session won, the other half lost. This created two sub-groups per session: one with a gain experience and another with a loss experience. The instructions for the experiment were displayed on the computer monitors during the experiment. Additionally, hard copies of the instructions were distributed. Communication between the participants was not allowed.

Participants played 16 rounds of the market entry game described above. In each round they were re-matched with two other opponents. The only information they received about their opponents was whether they experienced a gain or loss in the lottery prior to the market entry game. Participants were confronted with all possible combinations of opponents (gain/gain; gain/loss; loss/loss). All other information, like age and gender (in the mixed-sex sessions) was unknown. Participants did not receive feedback between rounds in order to avoid learning effects. The results of each round were presented in a table at the very end of the experiment. Participants were able to explicitly state mixed strategies in form of entry probabilities. This method has been also used by Anderhub et al. (2002) and Schade et al. (2010) and is called explicit mixing (cf. Camerer 2003). In each round participants could determine the proportions of ‘Entry’-balls and ‘No-Entry’-balls in a 100-ball urn to state their entry decisions. If an Entry-ball was drawn from the urn the player entered the market. If a No-Entry-ball was drawn the player did not enter the market. After the market entry game, participants answered a questionnaire on their beliefs about the entry behavior of others, and a second questionnaire including basic statistical data like age and gender. Furthermore, participants’ risk propensity was measured in accordance to Holt and Laury (2002). At the end of the experiment, one of the sixteen rounds of the market entry game was randomly selected for the final payoff. The final payment included the participant’s payoff from the market entry game and the Holt and Laury (2002) task. Table 1 below shows the order of the different parts of the experiment.

TABLE 8. EXPERIMENT

Arrival:	Show-up fee was paid
Part 1:	Lottery [inducing random gain and Loss experience]
Part 2:	Market entry game [16 rounds with varying opponent constellations]
Part 3:	Belief questions
Part 4:	Holt and Laury (2002) test on risk aversion
Part 5:	Demographic questionnaire
Part 6:	Overview of all results, random choice of payoff-relevant round, payments

3.3.4 Samples and sessions

The experiment was conducted with 90 participants: 18 entrepreneurs and 36 non-entrepreneurs in mixed-sex sessions and 12 female entrepreneurs and 24 female non-entrepreneurs in single-sex sessions. The control sessions with only female participants served as a robustness check for our results and tested whether women were influenced by the gender composition of the group they interacted with (cf. Gneezy at al. 2003). The entrepreneurs sample consisted of small business owners from the service, consulting, and technology industry. The number of employees per business was between 10 and 50. All of the entrepreneurs were founders and managers of their companies. The student samples consisted of undergraduate and graduate students from various fields. The experiments were programmed and conducted using the software z-Tree (Fischbacher 2007). All sessions were run in the experimental laboratory of a German university.

3.4 Results

Analyzing the data we ran GLS random-effects linear regressions in STATA. The dependent variable entry represents the stated *entry probability* [0;1] of the participants in the respective round. The between-subjects variables are *group* (entrepreneurs = 1; non-entrepreneurs = 0), *gender* (female = 1; male = 0), and *own experience* (gain = 1; loss = 0). As a robustness check we also considered the gender mix in sessions via *gendergroup* (male = 0; female in mixed-sex session = 1; female in single-sex session = 2). Risk propensity was measured in accordance to Holt and Laury (2002). Participants' entry beliefs for players with different pre-game experiences were gathered in form of percentage estimates via a questionnaire at the end of the experiment. The dummy variable *opponents' experience 1* represents rounds against one opponent with a gain and one opponent with a loss experience while *opponents' experience 2* represents rounds against two opponents with a gain experience. Correlations between *'risk aversion'* and *'group'*, *'risk aversion'* and *'sex'*, and *'risk aversion* and *'own experience'* were insignificant. Differences in risk propensity between entrepreneurs and non-entrepreneurs and between men and women were also insignificant.

Model 1 contains only own and opponents pre-game experiences and shows that participants with a gain experience entered less than participants with a loss experience. People entered more when playing against one opponent with a gain and one opponent with a loss experience (*opponents' experience 1*) or playing against two opponents with a gain experience (*opponents' experience 2*) as compared to rounds playing against two opponents with a loss experience. Model 2 additionally considers *group* and *gender*. Results show that while *gender* has a significant effect on entry – women enter less than men – while being an entrepreneur has not. Model 3 shows that the interaction of *group* and *gender* is not significant, i.e., the gender difference in entry is not smaller within the group of entrepreneurs. Model 4 further controls for *risk aversion* which had a significant negative influence on entry. In model 5 we consider interaction effects of *opponents' experience1* and *opponents' experience2* with *gender*. While the interaction of *opponents' experience1* and *gender* is significant the interaction between *opponents' experience2* and *gender* is not. Other interactions of the independent variables did not reach statistical significance.

TABLE 9. RANDOM-EFFECTS LINEAR MODELS

MODEL	(1)	(2)	(3)	(4)	(5)
own experience (0/1)	-0.078*(0.427)	-0.070*(0.042)	-0.068*(0.042)	-0074*(0.449)	-0.073*(0.045)
opponents' experience1 (0/1)	0.060**(0.018)	0.060**(0.018)	0.060**(0.018)	0.052**(0.019)	0.120**(0.040)
opponents' experience2 (0/1)	0.063**(0.021)	0.063**(0.021)	0.063**(0.021)	0.067**(0.022)	0.090*(0.046)
group (0/1)		0.016 (0.045)	0.092 (0.089)	-0.006 (0.048)	0.005 (0.048)
gender (0/1)		-0.094*(0.049)	-0.058 (0.061)	-0.315*(0.197)	-0.015 (0.063)
*group*gender*			-0.102 (0.102)		
risk aversion				-0.074**(0.028)	-0.044**(0.015)
*Risk aversion*gender*				0.042 (0.033)	
*opponents' exp.1*gender*					-0.089**(0.046)
opponents'					-0.030 (0.052)
Constant	0.473***(0.033)	0.535 ***(0.051)	0.507 ***(0.058)	0.962***(0.166)	0.746***(0.100)
σ_u	0.190	0.187	0.187	0.186	0.187
σ_e	0.282	0.282	0.282	0.284	0.284
ρ	0.311	0.306	0.306	0.300	0.303
χ^2	15.86	19.75	20.74	28.90	31.36
Number of observations	1440	1440	1440	1280	1280
Number of subjects	90	90	90	80	80

Dependent variable = entry

Random-effects specification = subject id

$^{***}p<0.001$; $^{**}p<0.01$; $^{*}p<0.05$

Running additional regressions and testing behavior of female participants in mixed-sex sessions versus single-sex sessions, we found no significant influence on entry behavior. Reaction patterns to opponents' experiences, however, tend to be less structured within the single-sex groups. Here, female entrepreneurs and female non-entrepreneurs seem to have been less sure about what an appropriate reaction to different opponent types might be as indicated in Figure 7, where female single sex groups are depicted in (c) and (f).

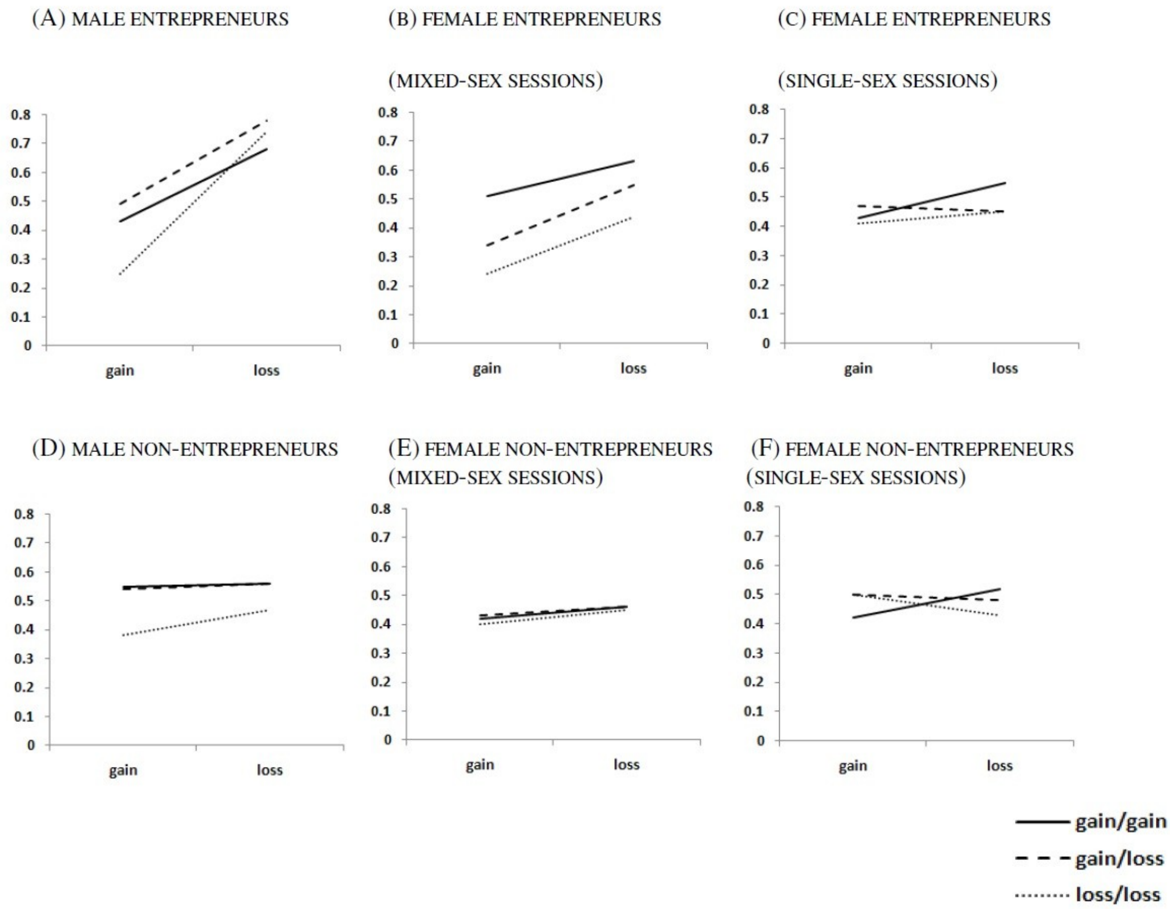

FIGURE 7. MEAN ENTRY RATE IN ROUNDS AGAINST OPPONENTS WITH DIFFERENT EXPERIENCES

Figures 7 (a) and (b) show that male entrepreneurs reacted more to own loss experiences than female entrepreneurs. Reacting to the prior experiences of their opponents male entrepreneurs entered most when being confronted with a mixed opponent group (gain/loss), while in mixed-gender sessions female entrepreneurs' entry patterns are highly consistent with assuming that players with a loss experience enter more than players with a gain experience.

Analyzing entry beliefs, we find that most participants believed that players with a loss experiences would enter more than players with a gain experience (see Table 10 below and for a more detailed overview Table 12 in the appendix). These overall beliefs are consistent with the general reaction patterns observed with most of the participants who entered less when playing against opponents with a loss experience and more when playing against opponents with a gain experience. An additional analysis including individuals' beliefs about the entry rates of participants with a gain experience and about the entry rates of participants with a loss experience confirms these effects: *belief entry gain* ($F_{1,141} = 33.7$; $p < 0.001$) and *belief entry loss* ($F_{1,141} = 15.6$; $p < 0.001$) had a large and highly significant main effect on entry as well as highly significant effects on entry patterns with respect to opponents' experiences (Greenhouse-Geisser correction: ($F_{2,141} = 11.9$; $p < 0.001$; $F_{2,141} = 34.1$; $p < 0.001$ respectively). The directions of the effects reported above remain. Participants with a loss experience have a slight tendency to better predict entry behavior of other participants with a loss experience. This tendency is however not statistically significant. Women's beliefs about entry rates of participants with a loss experience are significantly lower than the beliefs stated by men ($t = 2.68$; $p < 0.01$), the confidence interval is [0.0449666; 0.3015935]. Beliefs for participants with a gain experience did not significantly differ between men and women.

TABLE 10. OVERVIEW ENTRY BELIEFS

SAMPLE	GENDER		OWN EXPERIENCE	BELIEF ENTRY OF PARTICIPANTS WITH GAIN EXPERIENCE	BELIEF ENTRY OF PARTICIPANTS WITH LOSS EXPERIENCE
Entrepreneurs	male		gain	0.44	0.44
			loss	0.49	0.67
	female	(mixed-sex sessions)	gain	0.47	0.56
			loss	0.48	0.55
	female	(single-sex sessions)	gain	0.55	0.52
			loss	0.35	0.65
Non-entrepreneurs	male		gain	0.47	0.61
			loss	0.50	0.62
	female	(mixed-sex sessions)	gain	0.46	0.49
			loss	0.44	0.41
	female	(single-sex sessions)	gain	0.56	0.61
			loss	0.48	0.57

Schade et al. (2010) reported that in their study women used mixed strategies much more often than men. They interpreted this finding as a potential insecurity of women about their entry decision. Analyzing the use of mixed versus pure strategies for our data we find that men and women in mixed-sex sessions did not differ significantly.

However, women in single-sex sessions used pure strategies significantly less often than women in mixed-sex sessions ($p < 0.05$; mean difference = -2.88; [-4.86869; -0.89520]). Furthermore, entrepreneurs used pure strategies more often than non-entrepreneurs but this difference did not reach statistical significance ($p > 0.10$).

Summarizing our results, we find that entry behavior is driven by gender (Hypothesis 1) while being an entrepreneur does not have a significant effect (Hypothesis 2). Contrary to our expectation, female entrepreneurs acted not more similar to male entrepreneurs than women and men in the non-entrepreneur sample (Hypothesis 3). Results show that own and opponents' pre-game experiences significantly affect entry behavior (Hypotheses 4 and 5): participants with a gain experience entered less than participants with a loss experiences. When playing against two opponents' with a loss experience participants entered less than when playing against one player with a gain experience and one with a loss experience or when playing against two opponents with a gain experience. Further analyses show that reactions to opponents' experiences were moderated by gender and that the results are relatively robust also for females in single-sex sessions. Entry beliefs are consistent with these behavioral patterns. Most participants – males and females – believed that players with a loss experience enter more than players with a gain experience.

3.5 Discussion

We find that behavior in the considered market entry scenario is driven by gender and not by being an entrepreneur. Entry decisions of female entrepreneurs were not more similar to those of male entrepreneurs than the entry decisions of women and men in general. This is surprising as the self-selection of female entrepreneurs and learning to compete in a male dominated field would suggest that they are more similar to male entrepreneurs. This finding indicates that female entrepreneurs are not necessarily more willing to take strategic uncertainty than other women and that other aspects might overweigh their gender specific reluctance to take strategic uncertainty. While the industry female entrepreneurs operate in does not account for this effect, an alternative explanation would be that the women in our sample have chosen to found their businesses in a less male dominated niche of their industry.

The result that entry did not significantly differ between entrepreneurs and non-entrepreneurs is interesting as entrepreneurs have often been discussed to exhibit larger deviations from rational choice models than others (Busenitz and Barney, 1997, Parlich and Bagby 1995). The fact that we do not find significant behavioral differences indicates that entrepreneurs might not be so different from non-entrepreneurs in their decision making after all. This result is in line with other recent studies on entrepreneurs' decision making in incentivized experiments, which also found surprisingly small differences between entrepreneurs and non-entrepreneurs (Sandri et al. 2010, Boewe 2011, Boewe et al. 2011).

While our findings largely confirm the results of Schade et al. (2010), in our study, most male *and female* participants entered more when playing against players with a gain experiences than when playing against players with a loss experience. Their beliefs were largely consistent with these patterns and with the assumption of social projection. However, female non-entrepreneurs in mixed-sex sessions did not react much different to varying types of opponents (see also Figure 7e). In the study by Schade et al. (2010) the reactions of some women to their opponents' pre-game experience were almost opposed to those of men. Schade et al. (2010) argue that the behavior of these women might be explained by women interpreting the initial random lottery outcomes as a signal of the players' abilities to compete. A possible explanation for this difference in results might be that in our study participants were confronted with either a gain or with a loss experience. In the study by Schade et al. (2010) there were also "neutral" players who neither experienced a gain or a loss prior to the game. The players with a neutral history might have triggered results by enhancing the salience of gains and losses. Together with the results of Schade et al. (2010) our results give rise to further investigating the reference-dependence of beliefs (cf. Malter and Schade 2011).

The fact that we do not find significant differences in entry rates between women participating in mixed-sex sessions and women who participated in single-sex sessions further suggests that it is not women's unwillingness to enter when playing against potentially male opponents. Observed entry patterns with respect to opponents' experience (Figures 7 b, c, e, and f) rather indicate that women have difficulties with building beliefs about other women's entry behavior while they do not seem to be insecure about their beliefs when playing in mixed-sex sessions. This interpretation is supported by women's higher frequency of choosing mixed strategies in single-sex sessions.

There are two interesting additional results: (1) Overall entrepreneurs did not react stronger to own gain or loss experiences than non-entrepreneurs. This indicates that entrepreneurs might not be more affected by loss experiences than others. The question whether managers of larger companies exhibit a stronger or weaker tendency to increase risk taking after losses than entrepreneurs is still open and worth answering. (2) Women's entry rates were very close to or below the mixed strategy equilibrium while men sometimes overentered the market. Thus, women's entry behavior leads to generally fewer losses caused by overentry. Interestingly this result does not seem to be driven by women believing that their opponents enter more. Women's entry beliefs rather suggest that they judge the entry situation as more risky per se and think that all players will enter less.

3.6 Conclusion

We experimentally investigated gender differences in a strategic market entry scenario with random pre-game gain and loss experiences and tested whether gender differences are smaller with female and male entrepreneurs. We found that market entry behavior is driven by gender but not by being an entrepreneur. Women entered the experimental market less often than men. Contrary to our expectation, entry decisions of female and male entrepreneurs were not more similar than entry decision of men and women in general. Overall, participants with a gain experience entered less than participants with a loss experience. Most participants believed that players with a loss experience would enter more than players with a gain experience. Their entry patterns were largely consistent with these beliefs. The result that being an entrepreneur did not significantly influence behavioral differences indicates that entrepreneurs might not be so different from non-entrepreneurs in their decision making after all.

References

Allen, I.E., Elam, N., Langowitz, N. and Dean, M., 2007. *Global Entrepreneurship Monitor: Report on Women and Entrepreneurship*. Babson College, Babson Park, and London Business School, London.

Allport, F.H., 1924. *Social Psychology*. Cambridge, MA: Riverside Press.

Anderhub, V., Engelmann, D., and Güth, W., 2002. "An experimental study of the repeated trust game with incomplete information". *Journal of Economic Behavior and Organization*, 48, 197-216.

Blanchflower, D.G., 2004. "Self-Employment: More May Not Be Better". *Swedish Economic Policy Review*, 11, 15-74.

Boewe, S., Schade, C., Krantz, D., and Kostanovskaya, A., 2011. "Coordination under exogenous uncertainty: Experiments on R&D investment strategies of entrepreneurs and non-entrepreneurs". Unpublished manuscript.

Bonin, H., Dohmen, T., Falk, A., Huffman, D. and Sunde, U. 2007. "Cross-Sectional Earnings Risk and Occupational Sorting: The Role of Risk Attitudes". *Labour Economics*, 14, 926–937.

Bosma, N., Acs, Z., Autio, E. and Levie, J., 2009. *Global Entrepreneurship Monitor 2008: Executive Report*. Babson College, Babson Park, and Universidad de Desrollo.

Brandts, J., and Yao, L. 2010. "Ambiguous information and market entry: an experimental study". MPRA working paper 25276.

Busenitz, L.W., and Barney, J.B., 1997. "Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making". *Journal of Business Venturing*, 12, 9-30.

Byrnes J. P., Miller, D. C. and Schafer, W. D. 1999. "Gender differences in risk taking: A meta-analysis". *Psychological Bulletin*, 125, 367–383.

Camerer, C. and Lovallo, D., 1999. "Overconfidence and excess entry: an experimental approach". *The American Economic Review*, 89, 306-318.

Camerer, C. 2003. *Behavioral Game Theory*. Russell Sage Foundation, New York: Princeton University Press.

Cramer, J.S., Hartog, J., Jonker, N., and Van Praag, C.M., 2002. "Low risk aversion encourages the choice for entrepreneurship: an empirical test of a truism". *Journal of Economic Behavior and Organization*, 48, 29-26.

Eckel, C.C., and Grossman, P.J., 2008. "Forecasting risk attitudes: an experimental study using actual and forecast game choices". *Journal of Economic Behavior and Organization*, 68, 1-17.

Elston, J.A., Harrison, G., and Rutström, E.E, 2006. "Experimental Economics, Entrepreneurs and the Entry Decision". UCF Working paper.

Festinger, L., 1954. "A theory of social comparison process". *Human Relations*, 7, 117-140.

Fischbacher, U., 2007. "Z-Tree: Zurich Toolbox for Ready-made Economic Experiments". *Experimental Economics*, 10, 171-178.

Gneezy, U., Niederle, M., and Rustichini, A., 2003. "Performance in Competitive Environments: Gender Differences". *Quarterly Journal of Economics*, 118, 1049-74.

Harris, C. R., Jenkins, M., and Glaser, D., 2006. "Gender differences in risk assessment: Why do women take fewer risks than men?" *Judgment and Decision Making,* 1, 48-63.

Holt, C.A., and Laury, S.K., 2002. "Risk Aversion and Incentive Effects". *American Economic Review*, 92, 1644-1655.

Hudgens, G.A., and Fatkin, L.T., 1985. "Sex differences in risk taking: repeated sessions on a computer simulated task". *Journal of Psychology*, 119, 197-206.

Johnson, J., and Powell, P., 1994. "Decision making, risk and gender: Are managers different?" *British Journal of Management*, 5, 123-138.

Johnson, J. G., Wilke, A., and Weber, E. U., 2004. "Beyond a trait view of risk-taking: A domain-specific scale measuring risk perceptions, expected benefits, and perceived-risk attitude in German-speaking populations". *Polish Psychological Bulletin*, 35, 153-172.

Kahnemann, D., 1988. "Experimental economics: A psychological perspective". In R. Tietz, W. Albers and R. Selten (Eds.), *Bounded Rational Behavior in Experimental Games and Markets*, 11-18, Berlin: Springer-Verlag.

Koellinger, P., Minniti, M., and Schade, C., 2007. "I think I can, I think I can: Overconfidence and entrepreneurial behavior". *Journal of Economic Psychology*, 28, 502-527.

Koellinger, P., Minniti, M., and Schade, C., 2010. "Gender and entrepreneurial decisions". Forthcoming in *Oxford Bulletin of Economics and Statistics.*

Krueger, J., 2000. "The projective perception of the social world: a building block of social comparison processes". In M.J. Suls and L. Wheeler (Eds.), *Handbook of social comparison: theory and research*, 323-351, New York: Plenum/Kluwer.

Levin, I. P., Snyder, M.A., and Chapman, D. P., 1988. “The Interaction of Experiential and Situational Factors and Gender in a Simulated Risky Decision- Making Task”. *Journal of Psychology*, 122, 173–181.

Malter, D., and Schade, C., 2011. “Prior outcomes, beliefs, and strategic coordination: Causes and consequences of reference-dependent strategies in market entry games”. Unpublished manuscript.

Minniti, M., Arenius, P. and Langowitz, N., 2004. *Global Entrepreneurship Monitor: Report on Women and Entrepreneurship*. Babson College and London Business School.

Moore, D.A., and Cain, M.C., 2007. “Overconfidence and underconfidence: When and why people underestimate (and overestimate) the competition”. *Organizational Behavior and Human Decision Processes*, 103, 197-213.

Niederle, M., and Vesterlund, L., 2007. “Do Women Shy away from Competition? Do Men Compete too Much?” *Quarterly Journal of Economics*, 122, 1067-1101.

Niederle, M., and Vesterlund, L., 2011. “Gender and Competition”. *Annual Review in Economics*, 3, 601-630.

Parlich, L.E., and Bagby, D.R., 1995. “Using cognitive theory to explain entrepreneurial risk-taking: challenging conventional wisdom”. *Journal of Business Venturing*, 10, 425-438.

Powell, M., and Ansic, D., 1997. “Gender differences in risk behaviour in financial decision-making: An experimental analysis”. *Journal of Economic Psychology*, 18, 605-628.

Rapoport, A., Seale, D.A., Erev, I. and Sundali, J.A., 1998. “Equilibrium play in large group market entry games”. *Management Science,* 44, 119-141.

Reynolds, P.D., Bygrave, W.D., Autio, E., Cox, L.W. and Hay, M., 2003. *Global Entrepreneurship Monitor 2003: Executive Report*. Babson College, Babson Park, London Business School, London, Ewing Marion Kaufman Foundation, Kansas City.

Sandri, S., Schade, C., Mußhoff, O., and Odening, M., 2010. “Holding on for too long? An experimental study on inertia in entrepreneurs’ and non-entrepreneurs’ disinvestment choices”. *Journal of Economic Behavior and Organization*, 76, 30-44.

Sapienza, P., Zingales, L., Maestripieri, D., 2009. “Gender differences in financial risk aversion and career choices are affected by testosterone”. *Proceedings of the National Academy of Sciences*, 106, 15268-15273.

Schade, C., Schroeder, A., and Krause, K., 2010. “Coordination after gains and losses: Is prospect theory’s value function predictive for games?” *Journal of Mathematical Psychology*, 54, 426-445.

Schröder, A. 2008. *Die Verarbeitung von Gewinn- und Verlusterfahrungen in spezifischen Entscheidungs- und Spielsituationen – eine theoretische und experimentelle Analyse* - Dissertation, Humboldt-Universität zu Berlin, Wirtschaftswissenschaftliche Fakultät.

Selten, R., and Güth, W., 1982. “Game Theoretical Analysis of Wage Bargaining in a Simple Business Cycle Model”. Journal of Mathematical Economics, 10, 177-195.

Sexton, D. and Bowman-Upton, N., 1990. “Female and male entrepreneurs: Psychological characteristics and their role in gender related discrimination”. *Journal of Business Venturing*, 5, 29-36.

Weber, E., Blais, A., and Betz, N., 2002. “A domain-specific risk-attitude scale: measuring risk perceptions and risk behaviors”. *Journal of Behavioral Decision Making*, 15, 263–290.

Appendices

Appendix I: Tables

TABLE 11. OVERVIEW OF ENTRY RATES

SAMPLE	GENDER	OWN EXPERIENCE	OPPONENTS' EXPERIENCE: TOTAL	GAIN/GAIN	GAIN/LOSS	LOSS/LOSS
Entrepreneurs	male	gain	0.41	0.43	0.49	0.25
		loss	0.74	0.68	0.78	0.74
	female (mixed-sex sessions)	gain	0.36	0.51	0.34	0.24
		loss	0.54	0.63	0.55	0.44
	female (single-sex sessions)	gain	0.45	0.43	0.47	0.41
		loss	0.48	0.55	0.45	0.45
Non-entrepreneurs	male	gain	0.50	0.55	0.54	0.38
		loss	0.54	0.56	0.56	0.47
	female (mixed-sex sessions)	gain	0.42	0.42	0.43	0.40
		loss	0.46	0.46	0.46	0.45
	female (single-sex sessions)	gain	0.48	0.42	0.50	0.50
		loss	0.48	0.52	0.48	0.43

TABLE 12. OVERVIEW OF BELIEFS

SAMPLE	GENDER	OWN EXPERIENCE	BELIEF ENTRY PARTICIPANTS WITH GAIN EXPERIENCE: GAIN/GAIN	GAIN/LOSS	LOSS/LOSS	LOSS EXPERIENCE: GAIN/GAIN	GAIN/LOSS	LOSS/LOSS
Entrepreneurs	male	gain	0.23	0.60	0.50	0.50	0.37	0.47
		loss	0.34	0.56	0.56	0.70	0.70	0.60
	female *(mixed-sex s.)*	gain	0.47	0.48	0.46	0.66	0.66	0.35
		loss	0.56	0.44	0.43	0.59	0.51	0.55
	female *(single-sex s.)*	gain	0.64	0.53	0.49	0.55	0.48	0.53
		loss	0.31	0.42	0.32	0.60	0.69	0.65
Non-entrepreneurs	male	gain	0.20	0.63	0.58	0.55	0.64	0.65
		loss	0.50	0.56	0.44	0.67	0.65	0.54
	female *(mixed-sex s.)*	gain	0.43	0.52	0.43	0.43	0.55	0.49
		loss	0.42	0.47	0.44	0.44	0.37	0.41
	female *(single-sex s.)*	gain	0.52	0.58	0.57	0.62	0.62	0.59
		loss	0.42	0.52	0.51	0.61	0.54	0.56

Appendix II: Instructions – selected parts

Explanations of experimental procedures are added in *italics*. All payoffs were scaled up by factor 4.5 for the entrepreneurs. The values in parentheses varied depending on the participant's own result and the result of their opponents in the lottery.

At arrival in the experimental laboratory participants were paid a participation fee of 14 Euro in cash. After being seated at their computer desks, and before beginning with the actual experiment, they received following information:

> Welcome to our experiment!

> Lottery
>
> We will now conduct a lottery with the following features:
>
> There are 12 balls with numbers from 1 to 12 in a bingo cage. They will be drawn without replacement, i.e. once drawn a ball will not be placed back into the cage.
>
> A draw of a ball with the numbers 1-6 will result in a gain of 6 Euro*for you.
>
> A draw of a ball with the numbers 7-12 will result in a loss of 6 Euro*.
>
> The draws will take place in private at each participant's seat and will only be seen by that participant.

The individual lotteries were then conducted using a bingo cage and the respondents were informed about their outcome (gain or loss).

> Your ball has the number *'X'*. Hence, you *'won / lost'* 6 Euro.

You will play a game with changing counterparts. In addition to the rules of the game, the only information all of you will have is the outcome of the lottery we just conducted. In other words, you will always be informed about the outcome of your respective counterparts, as they will be about your outcome.

You are now starting with the experiment:

Please note:

Your decisions in this experiment will depend on your skill and luck, and will result in real payments of different amounts.

This experiment consists of several rounds.

While the results of each round will not be displayed, a summary of the whole experiment's results will be provided at the end of the experiment.

Out of all rounds, one will randomly be selected by the computer. Your game result in this randomly chosen round will then be added to your result of the lottery conducted at the beginning of the experiment.

At the end of the experiment, the experiment's supervisor will settle your account by paying out or collecting the payments from you.

You will find a red button at the bottom of each screen. When you understood and completed all tasks on that screen, press it to continue.

All information is anonymous and will be kept confidential.

Good luck.

You will now play a three person game over several rounds. Your opponent will change from round to round as previously and randomly determined by the computer.

Reminder

In the lottery conducted at the beginning of the experiment you {suffered a loss of 6 Euro / gained a profit of 6 Euro} which (in addition to any potential gains or losses made during the experiment) will be settled at the end of the experiment. Thus your current account balance is {- 6 Euro / + 6 Euro}.

Your Game Situation:

You and your two opponents have the choice of entering a market with limited demand. If all three of you decide to enter the market, everyone will suffer a loss of 6 Euro. If two of you decide to enter the market, the two entering players as well as the not entering player will receive 0 Euro. If only one of you decides to enter the market, he receives 6 Euro and the other two players who did not enter receive 0 Euro. If none of you decide to enter the market, all three players receive 0 Euro.

In the lottery at the beginning of the experiment, your two opponents in this round had the following results:

One opponent {suffered a loss of 6 Euro/ gained a profit of 6 Euro}.

Your other opponent {suffered a loss of 6 Euro/ gained a profit of 6 Euro}.

Your decision:

You will make your decision using of a virtual raffle drum. You will decide about the tickets in this drum. You can fill it with a total of 100 tickets (Entry tickets and NoEntry tickets). If an Entry ticket is drawn, you will enter the market. If a NoEntry tickets is drawn, you will not enter the market. Please, specify the content of the drum by stating the number of Entry and NoEntry tickets to be included:

Please indicate the number of Entry tickets to be placed in the drum: _______

Please indicate the number of NoEntry tickets to be placed in the drum: _______

Subsequently, multiple rounds with changing opponents were played. To ensure that participants noticed that conditions changed from round to round, the following screen was shown before to each round.

Information

Attention: In this round, the conditions of the game have changed. Please pay close attention to the information concerning the outcomes.

4. Demand uncertainty in skill-based competition

Article 3:
Demand uncertainty in skill-based competition: An explanation for market over- and underentry

Sabrina Boewe

This paper investigates the effect of exogenous demand uncertainty on peoples' willingness to enter skill-based competition. A market entry experiment has been conducted to test the effect of demand uncertainty for markets that differ in expected demand, i.e., strength of competition. The results show that under risky information about the demand, people overenter markets with a small expected demand and strong competition, while they underenter markets with a high expected demand and weak competition. These findings are explained by people believing that competitors would shy away from entering highly competitive markets while assuming that they would overrun markets with weak competition. Overconfidence had a main effect on entry behavior but did not moderate reactions to market demand.

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4.1 Introduction

When entering competitive markets, people are confronted with two types of uncertainty[7]: ability uncertainty regarding their skills as compared to their competitors and demand uncertainty. For example, in academic job search, job market candidates are confronted with uncertainty about their ranking as compared to other applicants and they are also confronted with demand uncertainty concerning the number of offered positions in their field. Further examples are business start-up decisions where the future market demand is uncertain or applications for research funds where the applicants do not know the sum of funds that will be granted.

While the role of ability uncertainty has been extensively investigated[8] (cf. Moore and Healy 2008), scholars have only recently begun to study the influence of exogenous uncertainty on behavior in skill-based competition (e.g., Wu and Knott 2006, Karelaia and Hogarth 2010). Wu and Knott (2006) modeled entrepreneurs' entry decisions simultaneously accounting for ability uncertainty and exogenous demand uncertainty. They argue that entrepreneurs – while being risk-averse with respect to demand uncertainty – decide to start a business because they are risk-seeking with respect to ability uncertainty, i.e., because they are overconfident in their own skills. Their model predicts that entrepreneurs' overconfidence outweighs risk aversion with respect to demand uncertainty and leads to excess market entry when the degree of ability uncertainty is comparable to that of demand uncertainty. Testing their model with a data from the banking industry, Wu and Knott find empirical support for their predictions. A different type of exogenous uncertainty is examined by Karelaia and Hogarth (2010). Based on the idea that people receive a signal about their relative skills, Karelaia and Hogarth (2010) experimentally investigate how uncertainty about the degree to which a person's skills actually matter for her ranking, i.e., the signal quality, influences entry decisions. They find that uncertainty about the signal quality increases entry rates for people with initially low ranks but does not have a large effect on people with initially

[7] In this paper the term 'uncertainty' is used as an umbrella term for risk where probabilities of an event are known, and all forms of ambiguous situations where probabilities are unknown.

[8] To the authors best knowledge there is no comprehensive literature overview of this research stream. Moore and Healy (2008) give a very good overview of the literature on overconfidence.

high ranks. While the behavior of low-ranked individuals is in line with predictions and to a large degree explained by rationality, no final conclusion could be drawn for the entry behavior of high-ranked individuals. As competition typically takes place in an inherently uncertain environment it is necessary to better understand how people deal with exogenous uncertainty in skill-based competition, and how this impacts on the outcome of competition. The results of Karelaia and Hogarth (2010) emphasize the need for further research on this topic.

This paper experimentally investigates how exogenous demand uncertainty influences skill-based competition. The focus thereby is on examining the interplay between the strength of competition and demand uncertainty. In a market entry experiment with skill-based payoffs, demand uncertainty is varied between subjects while the expected demand is varied within subjects. Effects of overconfidence have been controlled for by comparing entry behavior before and after partial feedback about the true skill-rank of participants. The results show that while entry is almost linearly increasing in expected demand when demand is given, under demand uncertainty entry is instead s-shaped with asymmetric effects for extreme values of expected demand. Under demand uncertainty people overenter markets with a low expected demand where competition is intense and they underenter markets with a high expected demand where competition is weak. Surprisingly, this over- and underentry was not moderated by the skill level or by the degree of overconfidence. The results are discussed in the context of previous findings on skill-based competition, excess market entry and demand uncertainty. Implications are discussed for behavior under different market conditions.

The remainder of the paper is organized as follows: the next section gives a brief overview of previous research on uncertainty in skill-based competition. Section three contains details on the experimental design and procedure, and the underlying model. Section four presents the data analysis and the results, followed by a discussion of the findings of this study and its possible implications.

4.2 Uncertainty in skill-based competition

4.2.1 Ability uncertainty

People prefer to bet on gambles involving skill components over equivalent gambles involving chance components (Cohen and Hansel 1959, Howell 1971). Based on this observation, Heath and Tversky (1991) formulated the *competence hypothesis*. The competence hypothesis states that people prefer betting on their own judgments over an equiprobable chance device when they consider themselves knowledgeable in the respective domain of judgment. They explained this preference with people's psychic payoffs of satisfaction or embarrassment related to the attribution of credit and blame. If a person is competent in a certain domain, success will be attributed to skill and failure will sometimes be attributed to chance. If a person is not competent, success will be attributed to chance while failure will be attributed to a lack of skill. Heath and Tversky (1991) proposed that the balance of credit and blame is most favorable when a person is competent, leading to a pronounced preference for ability uncertainty over exogenous uncertainty in this domain. In a number of experimental studies they found evidence for the competence hypothesis. But even in domains where people are no experts, i.e., in a general knowledge quiz or logic puzzles, they have been found to prefer skill components over random components (Cohen and Hansel 1959, Howell 1971, Camerer and Lovallo 1999). The systematic approach of Camerer and Lovallo (1999) helped to quantify how much this behavior is driven by people's preference to bet on themselves and their pronounced willingness to do so when they feel competent. In their seminal article, Camerer and Lovallo (1999) studied how people's beliefs about their relative competence affect their decisions to enter skill-based competition. They experimentally tested the hypothesis that market overentry results from people acting on overconfidence about their relative skills. For their experiment, they combined the experimental paradigm of the classic market entry game (Selten and Güth 1982; Kahneman 1988; Rapoport 1995; Rapoport et al. 1998; Sundali et al. 1995) with skill-based payoffs that are also used in tournaments. In their experiment, participants simultaneously decided about entering or not entering an experimental market where payoffs from entering depended on the participant's 'rank'. The *c* best ranked entrants made a profit from entering. All other entrants made a loss. Thus, only participants who believed to be among the *c* best ranked entrants should enter. In some rounds, ranks depended on a chance device (random condition) and in others on participants' relative skill compared to that of other players in a logic puzzle, trivia quiz, or sports questions (skill condition). Importantly, these ranks were determined after the entry decisions were made. Hence, when making their entry decisions, participants did not know their actual rank, but had to base their decision on their belief about their relative performance. Camerer and Lovallo (1999) compared entry rates in rounds with random ranks with the entry rates in rounds with skill ranks within subjects. They showed that entry rates were significantly higher in rounds where payoffs were based on relative skill (skill condition) than in rounds with random ranks (random condition), leading to over-entry and negative industry profits in most rounds with skill-based payoffs. Furthermore, they compared entry rates of participants that were recruited via standard recruiting instructions with participants that were recruited using a 'self-selection' instruction. In the self-selection condition, students were asked to participate in an experiment in which performance on sports or current event trivia would determine their payoff. By this comparison they tested whether the entry differential between rounds with skill ranks and rounds with random ranks is larger for groups that self-selected into the task because they considered themselves as especially competent in this domain. Indeed, they found that the gap between entry rates in both conditions was three times larger in the self-selection group, a finding they explained by peoples' tendency to neglect whom they are competing against und thus to underestimate the ability level among their competitors. Camerer and Lovallo (1999) coined the term *reference group neglect* for this phenomenon and trace it to people neglecting that their competitors self-selected into the task as well. Their results support the hypothesis that *overconfidence in own relative skill* and reference group neglect lead to excess market entry. This phenomenon is especially pronounced in domains into which people have self-selected and in which they feel competent in[9]. With their study Camerer and Lovallo (1999) developed a rich experimental paradigm to investigate self-confidence in skill-based competition that has stimulated research and an ongoing debate about the origin of market overentry (cf. Moore and Healy 2008). Some scholars see the origin of excess

[9] Alternative interpretations of the findings of Camerer and Lovallo (1999) are discussed by Hogarth and Karelaia (2009).

market entry in people's myopic self-focus (Moore et al. 2007) or in their underestimation of competitors (Camerer and Lovallo 1999, Bolger et al. 2008), and some trace it back to psychological payoffs of credit and blame and their perceived competence (Heath and Tversky 1991, Grieco et al. 2007) or ego-utility (Koeszegi 2010). Others have discussed the distorted error distribution with entry decisions (Soll 1996) and highlighted the influence of environmental aspects such as task difficulty (Ferrell, 1994; Ferrell & McGoey, 1980; Suantak, Bolger, & Ferrell, 1996, Moore et al. 2007) and task representativeness (Gigerenzer et al. 1991). Further perspectives include the conditions under which people sample and derive their beliefs (Hoffrage 2011) or the signal quality of their own ability (Karelaia and Hogarth 2010).

4.2.2 Exogenous uncertainty

An extensive body of literature deals with peoples' preferences for ability uncertainty over exogenous uncertainty. The interplay between these two types of uncertainty has been widely neglected. Often skill-based competition involves both, ability and exogenous uncertainty. Explicitly accounting for ability and exogenous demand uncertainty, Wu and Knott (2006) investigate entrepreneurs' market entry decisions and analyze how different preferences for ability and demand uncertainty affect decision outcomes. They aim at reconciling the risk-bearing characterization of entrepreneurs with the stylized fact that entrepreneurs exhibit conventional risk aversion profiles. Similarly to March and Shapira (1987), they argue that being risk-averse with respect to exogenous uncertainty, entrepreneurs are overconfident and apparently risk-seeking when it comes to ability uncertainty. Their model suggests that entrepreneurs' overconfidence outweighs risk aversion with respect to demand uncertainty when the degree of ability uncertainty is comparable to the degree of demand uncertainty. Testing their model with a large dataset from the banking industry, Wu and Knott (2006) find that people in the aggregate behave as their model predicts: risk-averse with respect to demand uncertainty and apparently risk-seeking or overconfident with respect to ability uncertainty. A high demand uncertainty and a low ability uncertainty lead to insufficient entry. When demand uncertainty is low and ability uncertainty is high they find excess entry. Due to the structure of their data, conclusions for individual decision making are limited.

Karelaia and Hogarth (2010) demonstrate how peoples' willingness to enter skill-based competition is influenced by the degree to which skills matter for the ranking. Based on the idea that people receive a signal about their relative skills, Karelaia and Hogarth (2010) investigate the influence of the signal quality on peoples' willingness to enter competition. They consider exogenous uncertainty that perturbs relative skill-ranks and determines which final rank people will actually hold. Thereby, they experimentally manipulate the signal quality people receive. For people with low skills, a low signal quality is more likely to increase their final rank thereby increasing their chances of success when entering. The effect of high-skill individuals is reversed. Their chances of success reduce with a low signal quality. Karelaia and Hogarth (2010) find that the additional uncertainty about the final ranks increases entry rates for people with initially low ranks, but does not have a large effect on people with initially high ranks. To a large degree the behavior of lower ranked individuals is congruent with rational decision making. The behavior of the high ranked individuals is, however, not in line with the predictions. Karelaia and Hogarth (2010) discuss this finding without coming to a finite conclusion. The results of Karelaia and Hogarth (2010) demonstrate the importance to better understand how people deal with exogenous uncertainty in skill-based competition.

4.2.3 Demand uncertainty and the strength of competition - Hypotheses

This study focuses on the interplay between demand uncertainty and the strength of skill-based competition. Many competitive situations involve uncertainty about the size of the future market, the number of positions in a certain field, or other resources for which people compete. This paper examines whether people are more or less willing to enter skill-based competition when they face risky as compared to certain information about the demand. Thereby, the strength of competition, i.e., the size if the expected demand, is expected to mediate people's reaction to demand uncertainty.

Demand uncertainty alone should, ceteris paribus, reduce the willingness to enter skill-based competition for people who are risk-averse with respect to demand risk. People who are risk-seeking with respect to demand risk should more often enter. Riskiness of demand should not affect the behavior of risk-neutral people. In a market entry game without skill-based payoffs, Brandts and Yao (2010) have found that people entered more when information about the market capacity was ambiguous than when the information about the market capacity was risky. They explain their result by the increase of the complexity of strategic decisions in the ambiguous condition. Given the finding of Brandts and Yao (2010) people should enter more under demand risk as compared to certain demand information.

The strength of competition, i.e., the size of the expected demand, might also influence entry behavior. Two plausible ways in which the strength of competition might influence peoples' behavior are the following: On the one hand, people might shy away from entering a market with a small expected demand because chances of being sufficiently skilled are small. Similarly, people might overenter markets with a large expected demand because chances of being sufficiently skilled are high. On the other hand, one can argue that people who expect others to shy away from entering markets with a small expected demand should enter these markets relatively more. Similarly, if they expect their competitors to overenter markets with a large expected demand they should enter these markets relatively less. Some studies have reported on overentry into markets with a small capacity (e.g., Bolger et al. 2008, Pogrebna and Schade 2009). In these studies, the demand was given. Under demand uncertainty, people might be more sensitive to small and large capacities as they might include beliefs about their competitors' risk attitude in their considerations. Furthermore, the confidence level of people might moderate their reactions to demand uncertainty. Wu and Knott (2006) demonstrated that overconfidence in own skills might outweigh the risk aversion with respect to exogenous demand uncertainty. Based on these findings and consideration, the following hypotheses are tested:

HYPOTHESIS 1: *Demand uncertainty effects people's willingness to enter skill-based competition.*

HYPOTHESIS 2: *The size of the expected demand has a positive effect on entry.*

HYPOTHESIS 3: *The effect of demand uncertainty is moderated by the expected demand.*

HYPOTHESIS 4: *Peoples' entry behavior is influenced by their confidence level in their skills.*

HYPOTHESIS 5: *Reactions to the expected demand are moderated by the confidence level.*

4.3 Experiment

4.3.1 Experimental design and procedure

The experiment is based on the experimental paradigm of Camerer and Lovallo (1999). In order to test hypotheses 1, 2, and 3 demand uncertainty was varied between subjects and the expected demand was varied within subjects. One group received certain information about the demand c (certainty condition). Another group received risky information about the demand c (risky condition). Demand uncertainty was varied between subjects in order to avoid problems related to the comparative ignorance phenomenon[10]. The expected demand was varied also taking into account extremely small and extremely large markets. Behavior is assumed to be influenced by the possibility of extreme values of demand, i.e., by the possibilities of a zero demand or the possibility that all players might be able to enter at a profit and competition is non-existent. In these cases entry patterns should be more pronounced as they include the possibilities of a skill-independent loss and a skill-independent profit, respectively. To test hypothesis 4 and 5, participants' overconfidence was measured by comparing their entry rates before and after partial feedback on their true skill-rank. Direct elicitation of beliefs about peoples' absolute skill or rank forces them to calibrate, thereby changing subsequent entry behavior[11]. Thus, an indirect measurement was preferred. One group of participants received feedback on their own absolute skill, another group received information about the skill dispersion among their competitors. This partial feedback on

[10] According to the comparative ignorance hypothesis of Fox and Tversky (1995) ambiguity aversion is the result of a comparison with less ambiguous events, or with more knowledgeable individuals. In this view, ambiguity is largely an artefact caused by the within-subject design used in most experimental studies on decision making under ambiguity versus risk.

[11] The author is grateful to Christian Schade who highlighted this problem and related it to the Heisenberg's (1927) uncertainty principle.

true skill rank allows to disentangle effects of overestimating own absolute skills and underestimating the performance level of competitors[12] that have been discussed to cause market overentry in previous studies (Camerer and Lovallo 1999, Moore et al. 2007, Bolger et al. 2008).

The experiment was conducted in the experimental laboratory of the School of Business and Economics of a German university. Participants were recruited via an experimental database (ORSEE, Greiner 2004) and via online announcements. Eight sessions were run with 14 participants each, yielding 56 participants in each session and a total of 112 participants in the experiment. 45 percent of the participants were male, 55 percent were female. The majority of the participants had some experience with economic experiments but none of them had taken part in a market entry experiment before. The experiment was computerized using the z-Tree (Fischbacher 2007).

Upon arrival, participants were paid a show-up fee of 12 € in cash that they were asked to put in their pockets. They were then seated in random order at computer desks without visual contact to each other. Communication was not allowed throughout the experiment. All instructions were displayed on the computer monitors guiding participants through the experiment; additional hard copies of the instructions were distributed. Digital calculators were available on all computer screens. After some general instructions, participants started with the first part of the experiment.

In part one, participants completed a general knowledge quiz consisting of 14 binary choice questions knowing that their payoff from the subsequent experiment would also depend on their performance in this quiz. Having completed the quiz, participants did not receive any feedback about their performance. Part two of the experiment was the market entry game. After some general instructions and comprehension questions, participants were matched in groups of seven players. Then they played five rounds of the market entry game. In each round they decided on entering or not entering an experimental. The payoff from entering depended on the skill-rank of the participant and on the demand in the respective round. Ranks were determined by the participants'

[12] The effect of partial feedback on performance has been studied in other set-ups by Grieco and Hogarth (2009), and by Urbig et al. (2009).

performance in a general knowledge quiz. The player with the highest number of correctly answered questions obtained rank 1, the player with the second highest number of correct answers rank two, ect.. The demand *c* varied from round to round. In each round the *c* best entrants would make a gain of 7.50 € by entering, all further entrants would make a loss of 10 €. In half of the sessions participants were confronted with certain information about the demand (certainty condition), in the other half of the sessions participants received only risky information about the demand (risky condition). In each round participants were randomly re-matched with another group of six players. No feedback about the round outcomes or the number of entrants was given until the very end of the experiment in order to avoid learning effects.

After participants completed the first block of five rounds, they played a second block of five rounds. In this block, participants were given partial information about their true rank. Group (a) received feedback on their own number of correct answers in the quiz. Group (b) received information about the performance dispersion among their competitors.

In part three of the experiment peoples' beliefs about the number of entrants in each condition were elicited. For correct estimates the participants received a small additional payoff. In part four risk attitudes were elicited according to Holt and Laury (2002). Part five contained a demographic questionnaire. Finally, in part six participants received a detailed overview of the results of all rounds and feedback about their own and the reference group performance. A random device determined one of the rounds. Participants were paid for the market entry game in accordance to their payoff in this round. Payoffs from all parts were added and final payments were made privately for each participant. Table 13 gives an overview over the different parts of the experiment.

TABLE 13. EXPERIMENT OVERVIEW

Part 1:	General knowledge quiz [identical for all participants] 14 binary choice questions
Part 2:	Market entry game [two conditions: (1) and (2)] (1) Certain information about the capacity (2) Risky information about the capacity I 5 rounds with varying market capacities II 5 rounds with varying market capacities and additional information [two sub-groups: (a) and (b)] (a) Information about own skill (b) Information about skill dispersion in reference group
Part 3:	Belief elicitation, incentive compatible
Part 4:	Holt and Laury (2002), risk propensity measurement, incentive compatible
Part 5:	Demographic questionnaire
Part 6:	Overview of all results, random choice of payoff relevant round, payments

The order of quiz and market entry game differed from the original design of Camerer and Lovallo (1999). In the experiment by Camerer and Lovallo (1999) the quiz was conducted *after* the market entry game. In this experiment the quiz was conducted before, but participants did not receive feedback about their performance. This change in task order was made to avoid potential confound of overconfidence and effects of *illusion of control*. Previous research has shown that people prefer betting on future events rather than on past events (Rothbart and Snyder 1970). This finding has been attributed to peoples' *illusion of control* but can also be explained by people's aversion to take bets with outcomes that could generally be known but are not known to them (Heath and Tversky 1991, Fox and Tversky 1995). In order to avoid this potential confound, the general knowledge quiz was conducted before the market entry game. Also, this set-up is closer to some real world situation where people compete about resources based on their previous achievement. Examples for such situations are job markets, the competition about research funds, or applications for colleges or universities.

4.3.2 Nash equilibria

If players knew their rank, the best *c* players in a group should enter. All others should stay out. As ranks were unknown, entry decisions mirrored the players' beliefs about their ranks. Assuming, however, that players are risk-neutral and have common ignorant priors, i.e., that they believe to have equal chances to be among the *c* best-ranked players, following equilibrium predictions can be derived:

Each of the seven players decides whether to enter, denoted by strategy $s_i = 1$, or not to enter, denoted by $s_i = 0$. If a player decides to stay out of the market her payoff is zero. If a player decides to enter, the payoff from entering depends on her rank. If she is among the best *c* ranked entrants, she will gain 7.50 €, if not, she will lose 10 € by entering.

(7) $$\pi_i(s_i, m) = \begin{cases} 0 & \textit{if } s_i = 0 \\ 7.50€ & \textit{if } s_i = 1 \textit{ and } m \le c \\ \dfrac{7.50€c - 10€[m-c]}{m} & \textit{if } s_i = 1 \textit{ and } m > c \end{cases}$$

where π_i denotes the payoff for player *i* given his strategy choice s_i and the total number of entrants *m* including player *i*. The demand is given by c. If the total number of entrants does not exceed the demand, the average entrant's profit is 7.50 €. If the total number of entrants does exceed the demand, the payoff of the average entrant equals the industry profit divided by the number of entrants. The industry profit is the accumulated payoff (gains and losses) of all entrants, whereby *c* entrants make a profit of 7.50 € and (*m-c*) entrants make a loss of 10 €.

In equilibrium, players must be indifferent about entering or staying out of the market. If $m \le c$, entering is a dominant strategy as 7.50 € is more than 0 €. If *m* > *c*, the average player should be indifferent between entering and staying out when $(7.50€c - 10€[m-c]/m) = 0$. This happens when *m* = 1.75 *c*. Consequently, in pure strategy equilibria the number of entrants is m = 1.75 c; e.g., the highest integer of entrants below 1.75 c.

To derive the mixed strategy equilibrium, let $p(s_1)$ denote the probability with which each player selects to enter and let $p(s_0) = 1 - p(s_1)$ be the probability with which each player selects to stay out of the market. Then the probability that m players enter and N-m players stay out is

$$p(m) = p(s_1)^m \cdot (1 - p(s_1))^{N-m} \cdot \binom{N}{m} \tag{8}$$

In the mixed strategy equilibrium, players enter with probability p^* solving:

$$p^*(s_1) \cdot 7.5 + (1 - p^*(s_1)) \cdot \sum_{m>1.75c}^{N} \left[\frac{7.5c - 10[m-c]}{m}\right] \cdot p^*(s_1)^m \cdot (1 - p^*(s_1))^{N-m} \cdot \binom{N}{m} = 0 \tag{9}$$

Table 14 shows the total number entrants for which the players are indifferent between entering and staying out for different values of c, the number of entrants in pure strategy equilibria and the corresponding mixed strategy equilibrium.

TABLE 14. OVERVIEW EQUILIBRIA

c	m = 1.75 c	enter if	# ENTRANTS IN PURE EQUILIBRIA	MIXED STRATEGY EQUILIBRIA p^*
1	1.75	$m - 1 \leq 1.75$	1	0.14
2	3.50	$m - 1 \leq 3.50$	3	0.43
3	5.25	$m - 1 \leq 5.25$	5	0.71
4	7	*enter always*	6 or 7	-
5	8.75	*enter always*	7	-

In the experiment, the effect of demand uncertainty was tested by giving part of the participants risky information about the market capacity. Instead of the certain values of demand c=1, c=2, c=3, c=4, and c=5, they were told that the demand would be c = [0; 1; 2], c = [1; 2; 3], c = [1; 3; 5], c = [2; 4; 6], and c = [3; 5; 7], respectively. All possible values in a round would realize with a chance of 1/3. Assuming risk-neutral players formed expected values and believed other players to be risk-neutral, the equilibrium predictions above also hold for the risky condition.

4.4 Results

4.4.1 Independent variables

On average people answered 8.1 out of 14 questions correctly. Men gave on average one correct answer more than women (*Mean* men = 8.7; *Mean* women = 7.7). This difference was statistically significant, $t = -2.64$; $p < 0.01$. The gender gap in performance is surprising as the questions had been pre-tested and were chosen by task difficulty and gender neutrality. Previous research documented tournament specific gender differences in performance, especially in mixed gender groups (Gneezy et al. 2003, Niederle and Vesterlund 2007). The observed gender gap in performance is thus likely to be a result of the tournament character of the task in the actual experiment which was absent in the pre-test. Marginally significant gender differences were also found with respect to *risk aversion*; women being more risk-averse than men, $t = 2.11$; $p < 0.05$ (Mean men = 5.3; Mean women = 6.2). This result is in line with previous research (Eckel and Grossman 2002). Point-biserial correlations between *gender* and *skill* and *gender* and *risk attitude* are $r_{pb} = 0.244$ and $r_{pb} = -0.211$, respectively. *Gender* accounts of $R^2 = (0.244)^2 = 6.0$ percent of the variability in *skill* and $R^2 = (-0.211)^2 = 4.5$ percent of the variability in *risk attitude*. There are no gender differences with respect to participants' beliefs about the number of entrants.

4.4.2 Regressions

Several logit models of entry have been estimated to test Hypotheses 1 and 5. Subject-specific random-effects have been employed to control for unobserved heterogeneity[13]. The dependent variable *entry* is binary and coded with '1' when a participant decided to enter and '0' when a participant decided not to enter. *Demand risk* is coded '1' for risky information about demand and '0' for certain information about demand. The variable *skill* represents the number of correct answers in the quiz. Beliefs about the number of entrants for each capacity are captured by variable *belief*. The variable *overconfidence* represents the entry differences before and after the partial feedback about the rank. If a person decreased her mean entry probability in the second block of rounds after having

[13] All analyses have been run in STATA.

received feedback on either her or her reference groups' performance in the quiz, this variable is positive and indicates that the respective participants is overconfident. *Gender* is coded '1' for male participants and '0' for female participants. The correlations between *gender* and *skill* and *gender* and *risk attitude* are below 0.5. Also collinearity statistics report uncritical values (variance inflation factor VIF = 1.221 < 10; tolerance statistic = 0.819 > 0.2).

Models have been estimated for the entry data of the first five rounds. *Entry* is always the dependent variable. Model 1 contains *demand risk, capacity* and the interaction effect of *demand risk* and *capacity* as independent variables. Model 2 adds *skill*, *gender*, and *belief*. Model 3 additionally considers *overconfidence* and *risk aversion*. Finally, model 4 further includes interactions of *demand risk*demand*skill* and *demand risk*demand*overconfidence*. Table 15 shows the results.

TABLE 15. RANDOM-EFFECTS LOGIT MODELS

MODEL	(1)	(2)	(3)	(4)
Demand risk (0/1)	2.112^{***}(0.519)	2.161^{***}(0.532)	1.845^{**}(0.532)	1.859^{**}(0.538)
Demand	1.877^{***}(0.289)	2.072^{***}(0.319)	2.004^{***}(0.317)	2.025^{***}(0.321)
*Demand risk*demand*	-0.754^{***}(0.165)	-0.777^{***}(0.168)	-0.727^{***}(0.175)	-0.489^{*}(0.233)
Skill		0.177^{**}(0.062)	0.243^{***}(0.058)	0.393^{**}(0.116)
Gender (0/1)		0.564^{**}(0.259)	0.637^{**}(0.239)	0.637^{**}(0.240)
Belief entry		-0.161 (0.087)	-0.203^{*}(0.083)	-0.200^{*}(0.083)
Overconfidence			2.823^{***}(0.556)	2.852^{**}(1.081)
Risk aversion			-0.092^{*}(0.055)	-0.097 (0.055)
*Demand risk*demand*skill*				-0.030 (0.020)
*Demand risk*demand*overc.*				0.001 (0.190)
Constant	-4.943^{***}(0.886)	-6.667^{***}(1.044)	-6.197^{***}(1.075)	-7.442^{***}(1.387)
σ_u	0.728 (0.191)	0.639 (0.215)	0.007 (0.115)	0.004 (0.038)
ρ	0.139 (0.063)	0.111 (0.066)	0.000 (0.000)	0.000 (0.000)
χ^2	76.55	81.36	95.24	95.03
Number of observations	560	558	482	482
Number of participants	112	112	97	97

Dependent variable = entry (0/1)

Random-effects specification = subject id

$^{***}p<0.001$; $^{**}p<0.01$; $^{*}p<0.05$

Analyses show that people who were confronted with risky information about the demand were more likely to enter than people who had certain information about the market capacity; *demand risk* had a highly significant positive effect on entry. People were also more likely to enter when the expected demand was higher; *demand* had a highly significant main effect on entry. Thereby effect of *demand risk* was negatively moderated by *demand*. The higher the expected demand, the lower the positive effect of *demand risk* on entry. People with a higher skill level were more likely to enter than people with a low skill level. Men entered more frequently than women. Risk aversion had a negative influence in entry. Furthermore, people's *belief* about the number of entrants negatively influenced entry; the more other people they believed to enter the market the less they were likely to enter. Being *overconfident* had a highly significant positive effect. Interactions of *demand risk*demand*skill* and *demand risk*demand*overconfidence* were not significant. No other interactions have been found to be significant.

4.4.3 Numbers of entrants

Figure 1 shows the mean number of entrants as a function of demand. For the certainty condition, the mean number of entrants is almost linear in demand and between c and 1.75*c, except for c =1 where entry is slightly higher. This entry pattern is largely in line with the equilibrium predictions. Mean payoffs from entering are positive for all values of c except for c =1 where the mean payoff is just below zero with -0.64 €. For the risky condition, the relationship between the mean number of entrants and the expected demand is s-shaped: when the expected demand is low, i.e., when c = [0; 1; 2], people overenter the market. In this situation the average number of entrants is 3.5 leading to a loss of 5€ for the average entrant. When the expected demand is high, i.e., when c = [3; 5; 7], people underenter the market and do not fully use the profit opportunities. The average number of entrants is 3.9 in this situation. Figure 1 shows the linear and s-shaped relation of entrants and demand in both conditions.

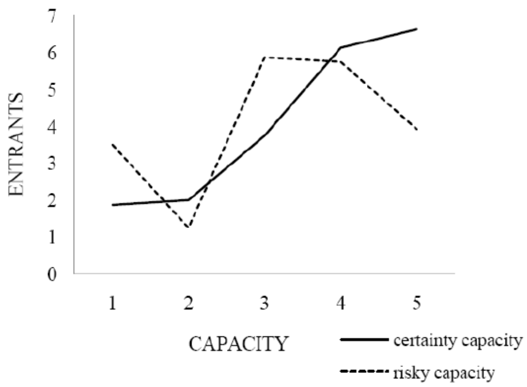

FIGURE 8. MEAN NUMBER OF ENTRANTS

4.4.4 Beliefs

In section II, two possible reactions to the extreme values of demand, c = [0; 1; 2] and c = [3; 5; 7], have been discussed. On the one hand, one can argue that people might shy away from entering a market with a very small expected demand where there is a 1/3 chance that all entrants will make a loss because the realized demand is zero. On the other, one can argue that people who expect others to shy away from entering in this situation might be more likely to enter themselves as they expect the number of entrants to be very small. For the other extreme, c = [3; 5; 7], corresponding arguments can be made: on the one hand, one can argue that people might try their luck entering a market with a very high expected demand where there is a 1/3 chance that all entrants will make a profit because the realized demand is seven. On the other hand, one can argue that people who expect others to excessively enter in this situation might be more likely to stay out themselves as they expect the number of entrants to be very high. Examining the beliefs of entrants and non-entrants in each of the situations shows that people seem to apply the second way of reasoning.

Figure 9 (a) shows that entrants' and non-entrants' beliefs in the certainty condition are almost linear in capacity and relatively accurate for small and medium sized markets. For large markets, participants underestimate the number of entrants. Figure 9 (b) shows the beliefs of participants in the risky condition. Here as well, entrants' and non-entrants' beliefs are increasing in capacity. However, while entrants' beliefs are almost linear, the beliefs of non-entrants are non-linear. The observed overentry at *c* = [0; 1; 2] can be explained by entrants believing that less than 1 other player would enter in this situation. The entrants' underestimation of the number of entrants seems to have caused the excess entry in this situation. The observed underentry at *c* = [3; 5; 7] can be explained by non-entrants believing that more than 5 other players would enter in this situation. The non-entrants overestimation of the number of entrants seems to have caused the underentry in this situation. Table 16 gives an overview of the beliefs.

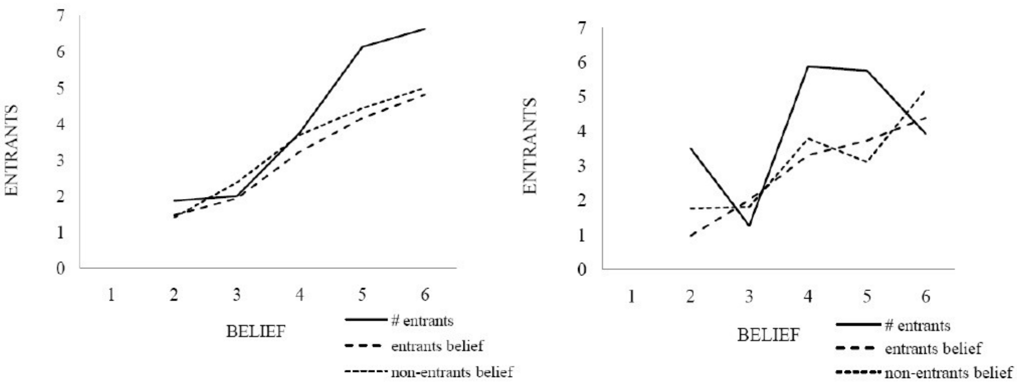

FIGURE 9. (A) BELIEFS CERTAINTY CONDITION / (B) BELIEFS RISKY CONDITION

TABLE 16. OVERVIEW BELIEFS

	CERTAINTY			RISK		
E[C]	# entrants	entrants belief	non-entrants belief	# entrants	entrants belief	non-entrants belief
1	1.87	1.47	1.41	3.50	**0.96**	1.75
2	2.00	1.94	2.38	1.25	2.00	1.80
3	3.75	3.23	3.69	5.87	3.30	3.78
4	6.13	4.16	4.43	5.75	3.72	3.10
5	6.63	4.81	5.00	3.92	4.38	**5.20**

4.4.5 Skills and overconfidence

The regression analysis above shows that the interactions of *demand risk*demand*skill* and *demand risk*demand*overconfidence* are not significant. Across groups (certainty condition and risky condition) people with higher skill levels do not react differently to increases in demand. The same accounts for overconfident people, i.e, Hypothesis 5 is not supported by the results. Overconfidence however has a significant positive main effect on entry (Hypothesis 4). Overconfidence is measured indirectly by comparing entry rates before and after partial feedback on the participants' true ranks. In half of the sessions, group (a), people receive feedback on their own number of correct answers, in the other half of the sessions, group (b), people receive feedback on the number of correct answers of the other players. Comparing individual entry rates before and after the feedback reveals the degree of absolute overconfidence for participants in group (a), and the degree of relative overconfidence for the participants in group (b). Table 17 shows entry rates before and after the feedback for the different sub-groups. In both conditions peoples' overconfidence levels are similar.

TABLE 17. MEAN ENTRY RATES AND OVERCONFIDENCE LEVELS

	CERTAINTY			RISK		
Feedback	Entry before feedback	Entry after feedback	Overconfidence	Entry before feedback	Entry after feedback	Overconfidence
own skill	0.61	0.56	0.05	0.61	0.57	0.04
skill reference group	0.56	0.53	0.03	0.55	0.48	0.07

An additional logit regression is estimated including entry data of the last five rounds to test the effect of partial information about the rank on entry (see Table 19 in Appendix I). Feedback and feedback type do not have a significant effect on entry.

4.5 Discussion

In this study, the effect of demand uncertainty on people's willingness to enter skill-based competition is moderated by the strength of competition in the respective market. Under demand uncertainty, people overenter small markets where competition is intense and they underenter large markets where competition is less intense. A similar effect is observed under certain information about the demand, however, this is less pronounced. The significant difference in behavior between the certain and risky condition is likely to be a consequence of the possibility of extreme values of demand in the risky condition. Here, an expected demand of one (c = [0; 1; 2]) would allow a 1/3 chance that independent of the skill-levels all of the entrants would make a loss by entering. An expected demand of five (c = [3; 5; 7]) would instead allow a 1/3 chance that independent of skill levels all players would make a profit by entering. The results show that the pattern of over- and underentry is related to participants' beliefs about the entry behavior of their competitors but not moderated by either their level of overconfidence nor by the true skill level. Thus, while people belief that their competitors' shy away from entering markets with intense competition leading them to enter more, at the same time they belief their competitors' to overrun markets with weak competition leading them to underenter these markets. These results are in line with previous studies that found people to overenter markets with small certain capacities (Bolger et al. 2008, Pogrebna and Schade 2009) and with studies that show market over- and underentry can be explained by peoples' beliefs' about their competitors entry behavior (Camerer et al. 2004).

In markets without skill-based payoffs, people have been found to enter more under ambiguous information than under risky information about the market capacity (Brandts and Yao 2010). Thus, the observed effects of demand uncertainty might be even stronger for markets where information about the realization of the demand is ambiguous.

Furthermore, previous studies have found that overconfidence in one's absolute skills affects entry behavior more than underestimating the skill level of competitors (Bolger et al. 2008). In this study, there was no significant difference between the effects of absolute overconfidence and reference group neglect, i.e., the type of feedback did not have a significant effect on entry behavior. This might be due to the different order of quiz and market entry game or due to the self-calibration question before the market entry game in Bolger et al. (2008). A pre-test of this study has shown that people entered less when being asked to state their expectation about their own performance. Alternative, the difference in findings might be also caused by the strong effect of the varying demand size on entry that was absent in Bolger et al. (2008) who examined certain capacities of four and eight in a 12-player market entry game.

Different to the study by Karelaia and Hogarth (2010), in the present study high and low ranked individuals do not react differently to the additional exogenous uncertainty. The difference between high- and low-skill individuals in the experiment of Karelaia and Hogarth (2010) was caused be the different consequence of the signal quality for the two groups. In this study, exogenous uncertainty does not lead to opposing consequences for the two groups.

Results show that overconfident individuals enter more often than underconfident individuals. This is in line with the many previous findings on overconfidence and entry decisions. However, overentry is only found in very few situations, when the expected capacity of the market is low. This result might be mainly driven by two aspects in the experimental design: (1) In the present experiment people did not self-select into the task which has been found to increased the entry rate and rates of overentry by factor three in Camerer and Lovallo (1999). (2) In the present study the effects of overconfidence and illusion of control have been disentangled. This was not the case in many of the studies that reported on high rates of overentry. Part of the effects found in previous studies might thus be caused by the simultaneous effect of overconfidence and people's preference for bets on outcomes that did not yet realize (Heath and Tversky 1991, Fox and Tversky 1995).

The gender differences that were found are in line with previous research on gender differences in competition (for an overview see Niederle and Versterlund 2011).

4.6 Conclusion

This study shows that people' reactions to demand uncertainty in skill-based competition differs with the expected strength of competition. People overenter markets with small expected demand and intense competition and underenter markets with high expected demand and weak competition. People's entry behavior can be explained by their beliefs about their competitors' reactions to the expected demand. Assuming that their competitors shy away from entering markets with a small expected demand they overenter these markets. Assuming that their competitors overrun markets with a high expected demand they underenter these markets. These findings are consistent with previous results of a market entry game without skill-based payoffs and with certain demand by Camerer et al. (2004). Under demand uncertainty the observed pattern of over- and underentry is much more pronounced than under certain demand conditions.

Overconfidence and skill level had significant main effects on entry but did not moderate reactions to different market sizes. These results show opportunities for further research on the influence of exogenous uncertainty in skill-based competition and about the influence of the strength of competition.

References

Bolger, F., Pulford, B.D., and Colman, A.M., 2008. "Market Entry Decisions: Effects of Absolute and Relative Confidence". *Experimental Psychology,* 55, 113-120.

Brandts, J. and Yao, L., 2010. "Ambiguous information and market entry: an experimental study". MPRA Working paper 25276.

Camerer, C. and Lovallo, D., 1999. "Overconfidence and excess entry: an experimental approach". *The American Economic Review*, 89, 306-318.

Camerer, C., Ho,T.-H., and Chong, J.-K., 2004. "A cognitive hierarchy model of games". *The Quarterly Journal of Economics*, 3, 861-898.

Cohen, J., and Hansel, M., 1959. "Preferences for different combinations of chance and skill in gambling". *Nature*, 183, 841-842.

Eckel, C. C., and Grossman, P. J., 2002. "Sex differences and statistical stereotyping in attitudes toward financial risk". *Evolution and Human* Behavior, 23, 281-295.

Ferrell, W.R., 1994. "Discrete Subjective Probabilities and Decision Analysis: Elicitation, Calibration and Combination". In G. Wright and P. Ayton (Eds.): *Subjective Probability*, 411-451. Chichester: Wiley.

Ferrell, W.R., and McCoey, P.J., 1980. "A model of calibration for subjective probabilities". *Organizational Behavior and Human Decision Processes*, 26, 32-53.

Fischbacher, U., 2007. "Z-Tree: Zurich Toolbox for Ready-made Economic Experiments". *Experimental Economics,* 10, 171-178.

Fox, C.R., and Tversky, A., 1995. "Ambiguity Aversion and Comparative Ignorance". *The Quarterly Journal of Economics*, 110, 585-603.

Gigerenzer, G., Hoffrage, U., and Kleinbölting, H., 1991. "Probabilistic mental models: A Brunswikian theory of confidence". *Psychological Review*, 98, 506-528.

Greiner, B., 2004. "The online recruitment system orsee 2.0 – a guide for the organization of experiments in economics*"*. Working paper, Department of Economics, University of Cologne.

Grieco, D., and Hogarth, R., 2009. "Overconfidence in absolute and relative performance: The regression hypothesis and Bayesian updating". *Journal of Economic Psychology,* 30, 756-771.

Grieco, D., Hogarth, R., and Karelaia, N., 2007. "Risk Taking and Excess Entry: The Roles of Confidence and Fallible Judgment", Working paper.

Heath, C., and Tversky, A., 1991. "Preference and Belief: Ambiguity and Competence in Choice under Uncertainty". *Journal of Risk and Uncertainty*, 4, 5-28.

Heisenberg, W., 1927. "Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik", *Zeitschrift für Physik*, 43, 172-198. English translation: J. A. Wheeler and H. Zurek, 1983. In *Quantum Theory and Measurement*, Princeton University Press, 62-84.

Hoffrage, U., 2011. "Recognition judgements and the performance of the recognition heuristic depend on the size of the reference class". *Judgement and Decision Making*, 6, 43-57.

Hogarth, R. and Karelaia, N., 2009. *Entrepreneurial success and failure. Confidence and fallible judgement.* Working paper, Universitat Pompeu Fabra, Barcelona.

Holt, C.A., and Laury, S.K., 2002. "Risk Aversion and Incentive Effects". *The American Economic Review*, 92, 1644-1655.

Howell, W. C., 1971. "Uncertainty from internal and external sources: A clear case of overconfidence". *Journal of Experimental Psychology*, 89, 240-243.

Kahneman, D., 1988. "Experimental economics: A psychological perspective". In R. Tietz, W. Albers & R. Selten (Eds.), *Bounded Rational Behavior in Experimental Games and Markets*, 11-18. Berlin: Springer-Verlag.

Karelaia, N. and Hogarth, R., 2010. "The attraction of uncertainty: Interactions between skill and levels of uncertainty in market entry games". *Journal of Risk and Uncertainty*, 41, 141-166.

Koeszegi, 2010. "Ego utility, overconfidence, and task choice". *Journal of the European Economic Association*, 4, 673-707.

March, J.G., and Shapira, Z., 1987. "Managerial Perspectives on Risk and Risk Taking". *Management Science*, 33, 1404-1418.

Moore, D.A., and Healy, P.J., 2008. "The Trouble with Overconfidence". *Psychological Review*, 115, 502-517.

Moore, D.A., Oesch, J.M., and Zietsma, C., 2007. "What competition? Myopic self-focus in market entry decisions". *Organization Science*, 18, 440-454.

Niederle, M., and Vesterlund, L., 2011. "Gender and Competition". *Annual Review in Economics*, 3, 601-630.

Pogrebna, G. and Schade, C., 2009. "Innovation, Entry into Multiple Markets and Unobserved Heterogeneity". SSRN working paper 1374409.

Rapoport, A., 1995. “Individual strategies in a market entry game”. *Group Decision and Negotiation*, 4, 117-133.

Rapoport, A., Seale, D.A., Erev, I., and Sundali, J.A., 1998. “Equilibrium play in large group market entry games”. *Management Science*, 44, 119-141.

Rothbart, M., and Snyder, M., 1970. “Confidence in the prediction and postdiction of an uncertain outcome”. *Canadian Journal of Behavioural Science*, 2, 38-43.

Selten, R., and Güth, W., 1982. “Game Theoretical Analysis of Wage Bargaining in a Simple Business Cycle Model”. *Journal of Mathematical Economics*, 10, 177-195.

Soll, J., 1996. “Determinants of Overconfidence and Miscalibration: The Roles of Random Error and Ecological Structure”. *Organizational Behavior and Human Decision Processes*, 65, 117-137.

Suantak, L., Bolger, F., and Ferrell, W.R., 1996. “The hard–easy effect in subjective probability calibration”. *Organizational Behavior and Human Decision Processes*, 67, 201-221.

Sundali, J., Rapoport, A, and Seale, D.A., 1995. “Coordination in Market Entry Games with Symmetric Players”. *Organizational Behavior and Human Decision Processes*, 64, 203-218.

Urbig, D., Weitzel, U., and Stauf, J., 2009. “What is your level of overconfidence? A strictly incentive compatible measurement of absolute and relative overconfidence”. Working Paper 09-20, Utrecht School of Economics.

Wu, B., and Knott, A.M., 2006. “Entrepreneurial Risk and Market Entry”. *Management Science*, 52, 1315-1330.

Appendices

Appendix I: Tables

TABLE 18. MEAN ENTRY RATES AND MEAN PAYOFFS (FIRST FIVE ROUNDS)

	CERTAINTY		RISK	
E[C]	Mean entrants	Mean payoff	Mean entrants	Mean payoff
1	1.87	-0.64 €	3.50	-5.00 €
2	2.00	7.50 €	1.25	7.50 €
3	3.75	4.00 €	5.87	-1.06 €
4	6.13	1.42 €	5.75	2.17 €
5	6.63	3.20 €	3.92	7.50 €

TABLE 19. RANDOM-EFFECTS LOGIT MODEL FOR ROUND 1-10

MODEL	COEF.	SE
Demand risk	2.541^{***}	(0.550)
Demand	2.026^{***}	(0.295)
*Demand risk*demand*	-0.894^{***}	(0.167)
Feedback type	-0.295	(0.246)
Skill	0.309^{***}	(0.067)
Gender	0.636^{*}	(0.267)
Constant	-7.955^{***}	(1.179)
σ_u	0.687	(0.202)
ρ	0.125	(0.064)
χ^2	82.12	
Number of observations	560	
Number of participants	112	

Dependent variable = entry (0/1)

Random-effects specification = subject id

$^{***}p<0.001$; $^{**}p<0.01$; $^{*}p<0.05$

Appendix II: Instructions – selected parts

Explanations of experimental procedures are added in *italic*. All payoffs were scaled up down by factor 3 for the non-entrepreneurs.

At arrival in the experimental laboratory participants were paid a participation fee in cash. After being seated at their computer desks, and before beginning with the actual experiment, they received following information:

> Welcome!
>
> In this experiment, you will be asked to take various decisions. At the end of the experiment you will be paid for your participation. The amount you will receive depends on the decision you have made and on the decisions other participants have made.
>
> The experiment consists of three parts. In the first part, you will take a knowledge quiz. In the second part, you will play a game with six other players. In the third part, you will be asked to compare different lotteries. In the end we will ask you a few further questions. The entire experiment will take about 60-90 minutes.
>
> After you have concluded all parts of the experiment we will clear the payoffs from each part of the experiment and pay out the final amount to you in cash.
>
> All information will be treated as strictly confidential. Your anonymity is being ensured at any time.
>
> Next

Participants then answered 14 binary choice quiz questions. They did not receive information about their results.

> Part 2: The Game
>
> In the second part of the experiment you will play 10 rounds of a 7-player game. In each round you will play against another randomly chosen group of 6 anonymous counterparts.
>
> Next

Part 2: The Game

Rules of the game:

In this game 7 players will decide simultaneously on enter a market or not. The market has a limited size, i.e., only a certain number of players can enter with profits. The rest who enters will suffer a loss. Whether you gain a profit or make a loss when you enter depends on the number of correct answers given in the quiz in part 1.

From all entrants only the ones who performed best in the quiz will make profits. The ones who enter the market and did worse in the quiz will suffer a loss. The number of players that can possibly make a profit (the so called market capacity c) might vary from round to round.

I.e., if the market capacity is c=3 the three best ranked players who enter the market will make profits and all the other players who enter will make a loss. If we have a market capacity of c=4 the four best ranked players will make profits while the rest who enters gets losses, and so on.

If a player decides not to enter he will make either profits or losses in this particular round.

None of the players either know their own number of correct answers from the quiz nor the number of correct answers of their counter players.

Next

Part 2: The Game

During the experiment you will not receive feedback about the results of previous rounds. Instead the results of all rounds will be summarized in an overview at the end of the experiment. One of the rounds will be randomly chosen. The profit/ loss that you achieved in this round will then be added or deducted from your payoff from the experiment. The other rounds will not be paid out.

Since every round could be chosen, please consider all decisions with equal attentiveness.

Next

Participants played 5 rounds with the following instructions:

Version (1)

Round 1

You and six other players will decide simultaneously to enter a market or not.

The market has a limited size so that only a certain number of players can enter with profits.

The payoffs for those who enter the market are determined in the following way:

According to number of right answers in the quiz, a rank is assigned to each entering player. The player with the highest number of correct answers is ranked number 1, the player with second highest number of correct answers is ranked number 2 and so on. In case several players have the same number of correct answers they will additionally be ranked by their speed answering the quiz. Thereby the fastest player gets the best and the second fastest player the second best rank and so on.

The **four best ranked entrants** (rank 1 to rank 4) will make a profit of 7.50 €. All other entrants will make a loss of 10 €.

In case of market entry:

	Rank of the player in the quiz						
C	1	2	3	4	5	6	7
4	7.50 €	7.50 €	7.50 €	7.50 €	- 10 €	- 10 €	- 10 €

In case of not-entering: If a player chooses not to enter he neither makes a profit nor a loss in this round.

Please decide now whether you want to enter the market or not:

Entry

No Entry

Version (2)

Round 1

You and six other players will decide simultaneously to enter a market or not.

The market has a limited size so that only a certain number of players can enter with profits.

The payoffs for those who enter the market are determined in the following way:

According to number of right answers in the quiz, a rank is assigned to each entering player. The player with the highest number of correct answers is ranked number 1, the player with second highest number of correct answers is ranked number 2 and so on. In case several players have the same number of correct answers they will additionally be ranked by their speed answering the quiz. Thereby the fastest player gets the best and the second fastest player the second best rank and so on.

Depending on the market capacity c either the six best ranked players (rank 1 to rank 6), the four best ranked entrants (rank 1 to rank 4) or the two best ranked entrants (rank 1 to rank 2) will make a profit of 7.50 €. All other entrants will make a loss of 10 €.

The market seize is unknown. Each of the three capacities might realize with 33.3% (i.e. in one third of all cases). Once each player has taken his decision the size will be determined via a random mechanism.

The possible payoffs are presented below.

In case of market entry:

	Rank of the player in the quiz						
c	1	2	3	4	5	6	7
2	7.50 €	7.50 €	- 10 €	- 10 €	- 10 €	- 10 €	- 10 €
4	7.50 €	7.50 €	7.50 €	7.50 €	- 10 €	- 10 €	- 10 €
6	7.50 €	7.50 €	7.50 €	7.50 €	7.50 €	- 10 €	- 10 €

In case of not-entering: If a player chooses not to enter he neither makes a profit nor a loss in this round.

Please decide now whether you want to enter the market or not:

Entry

No Entry

After five rounds, participants entered a second block of rounds in which they received partial feedback about their rank. They either received feedback about their own number correct answers in the general knowledge quiz (group a) or about the performance distribution in their reference group (group b):

Version (a)

New Information

Your result from the quiz: you have answered ‘x’ questions out of 14 correctly.

Next

Further Rounds

All players have just received information about their result in the quiz in part 1.

You will now continue playing the game for another five rounds. The same conditions apply as before:

In each round players are randomly re-matched so that you play against another group of 6 players in each round.

The results of each round will only be reported to you by the end of the experiment.

At the end of the experiment the payoff relevant round will be determined via a random draw.

Next

Version (b)

New Information

For each of the following rounds players will receive information on their counterparts' results from the knowledge quiz, i.e. the number of correct answers in the knowledge quiz.

Since you will be playing against different players in each round, you will receive information on your counterparts' results before each round.

Next

Further Rounds

In each of the following rounds players will be informed about their counterparts' number of correctly answered quiz questions (out of 14).

You will now continue playing the game for another five rounds. The same conditions apply as before:

In each round players are randomly re-matched so that you play against another group of 6 players in each round.

The results of each round will only be reported to you by the end of the experiment.

At the end of the experiment the payoff relevant round will be determined via a random draw.

Next

Example screen for reference group information:

Round 6

The following table presents the quiz results of each of your counterparts in this round.

For instance, you see how many questions (out of 14) your counterparts answered correctly.

Counterpart	Number of Correct Answers

Participants played five further rounds (round 6-10) receiving reference group information in each round.

5. Does 'ego' make the entrepreneur?

Article 4:

Does 'ego' make the entrepreneur?

Overconfidence, demand uncertainty and market entry

Sabrina Boewe

This paper investigates whether entrepreneurs have a higher willingness to enter skill-based competition under demand uncertainty than non-entrepreneurs. A special focus is on the role of reference group neglect, i.e., underestimating the skill level of one's competitors. The findings suggest that entrepreneurs do not significantly differ from non-entrepreneurs with respect to their willingness to enter skill-based competition, relative overconfidence and susceptibility to the reference group neglect. Instead, gender differences have been found. Results are discussed in the context of previous findings on entrepreneurs' overconfidence, market entry, and women's participation in entrepreneurial activities.

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5.1 Introduction

In the light of low average returns and high failure rates, explanations for entrepreneur's business entry decisions have been linked to a higher risk tolerance (Knight 1921, Khilstrom and Laffont 1979, Stewart and Roth 2001, Cramer et al. 2002), a different risk perception (March and Shapira 1987, MacCrimmon and Wehrung 1990, Kahneman and Lovallo 1993) and to entrepreneurs' susceptibility to a number of cognitive biases (Busenitz and Barney 1997, Baron 1998, Camerer and Lovallo 1999, Bernardo and Welch 2001, Hayward et al. 2006, Wu and Knot 2006, Koellinger et al. 2007). Among these biases the most important one is overconfidence, i.e., people's tendency to be overly optimistic about their own skills.

While the image of the entrepreneur as a risk seeker has been empirically refuted (Brockhaus 1980, Masters and Meier 1988, Miner and Raju 2004) and the relationship between risk perception and cognitive biases is still being debated (Simon et al. 2000), a number of studies provide evidence that entrepreneurs are indeed overconfident and overly optimistic about their chances of success (Cooper et al. 1988, Busenitz and Barney 1997, Wu and Knott 2006, Koellinger et al. 2007). Wu and Knott (2006) argue that business entry decisions can be explained by entrepreneurs' overconfidence outweighing their risk aversion with respect to demand uncertainty. Testing their model on the aggregate level, Wu and Knott (2006) find empirical support for their predictions. In an interview Brian Wu concludes: "in the end it's their overconfidence that drives them to be entrepreneurs"[14].

What these findings have shown is that overconfidence plays an important role for the decision to start a business. This has – often unintendedly – added weight to the notion of the entrepreneur as someone *particularly* overconfident in his own skills. However, there is no empirical evidence that entrepreneurs actually do overestimate their *relative skills* more than others. Indeed, there is some evidence that entrepreneurs might actually not differ from others in this regards (Elston et al. 2006). Also Wu and Knott note that they "[…] do not postulate that entrepreneurs differ from wage-earners on either

[14] Brian Wu was interviewed on the results of his study by Stacy Perman for Bloomberg BusinessWeek. The interview was published in February 2005. The interview was titled "Ego makes entrepreneurs?"

dimension [risk aversion or overconfidence]" (2006, p. 1318). But while the literature is full of examples of people acting on overconfidence (e.g., Svenson 1981, Kramer et al. 1993, Odean 1998) it is the entrepreneur who is characterized as especially overconfident (Busenitz and Barney 1997). Making a clear distinction between 'acting on overconfidence' and the notion of the entrepreneurs as someone particularly overconfident is important from a theoretical viewpoint as well as for institutional decision makers such as investors and policy makers who judge entrepreneurial ventures. This paper contributes to the literature on entrepreneurial overconfidence by clarifying the distinction and by testing potential differences in *relative overconfidence* between entrepreneurs and non-entrepreneurs.

So far, there are two studies that actually compared entrepreneurs and non-entrepreneurs susceptibility to being overconfident: Busenitz and Barney (1997) and Elston et al. (2006). Busenitz and Barney (1997) examined entrepreneurs' ability to assess their own skills in a general knowledge quiz. They found that entrepreneurs overestimate their absolute skills more than managers of large organizations. In competitive markets, however, success and failure depend on being better than one's competitors, i.e., on relative skills. Overconfidence in one's relative skills can be caused by either overestimating one's own absolute skills or by underestimating the ability level among one's competitors, a phenomenon that has been called *reference group neglect* by Camerer and Lovallo (1999), or by both together. Thus, while overconfidence in absolute skills is important, the relevant factor to look at when it comes to competition is relative overconfidence. Entrepreneurs' susceptibility to relative overconfidence has been studied by Elston et al. (2006) who conducted experiments at two large start-up conventions. Using the general experimental design of Camerer and Lovallo (1999) they found that entrepreneurs were not more overconfident with respect to their relative skills than a test-group of non-entrepreneurs. Now, given that relative overconfidence can be caused by overestimating one's own absolute ability and/or by underestimating one's competitors, the results of Busenitz and Barney (1997) and Elston et al. (2006) lead to the following inference: if entrepreneurs are more overconfident in their absolute skills than non-entrepreneurs (Busenitz and Barney 1997) and at the same time not more prone to relative overconfidence (Elston et al. 2006), they should c.p. be *less* susceptible to reference group neglect than non-entrepreneurs. An alternative explanation is that the managers in Busenitz and Barney (1997) were less overconfident in their absolute skills than the non-entrepreneurs in Elston et al. (2006).

To clarify these potential differences in relative overconfidence, this study experimentally tests entrepreneurs' and non-entrepreneurs' willingness to enter skill-based competition focusing on the role of reference group neglect. This requires disentangling the effects of absolute and relative overconfidence. As a first step, the literature on entrepreneurial overconfidence is reviewed outlining the different concepts of overconfidence that have been used and how these results relate to each other. In a second step, a controlled laboratory experiment has been conducted to test whether entrepreneurs are more prone to act out of relative overconfidence than non-entrepreneurs. The effect of reference group information on entry behavior was tested to measure individual levels of reference group neglect. In order to compare the findings to previous results of Busenitz and Barney (1997), Elston et al. (2006), and Wu and Knott (2006) the experimental design incorporates measuring relative skills via a general knowledge questionnaire and giving ambiguous information about the size of the experimental market.

The results show no significant differences in relative overconfidence and reference group neglect between entrepreneurs and non-entrepreneurs. They are in line with the results of Elston et al. (2006) and with other incentivized studies that suggest entrepreneurs' decisions not to be so different from non-entrepreneurs' decisions after all (Moore et al. 2007, Holm et al. 2010, Schade and Boewe 2011). Differences in relative overconfidence were instead mainly driven by gender; a result that is consistent with previous research on overconfidence in non-entrepreneurs. Furthermore, no overentry could be observed under demand uncertainty. This finding is argued to be driven by the generality of the task as entry rates have been found to be higher in markets in which participants self-select (Camerer and Lovallo 1999) like the market considered by Wu and Knott (2006).

The next section gives an overview of the literature on entrepreneurial overconfidence. Section three describes the experiment. The results are presented in section four followed a discussion of the findings in section five. Finally, section six contains the conclusion.

5.2 Entrepreneurial overconfidence

The term overconfidence has been used in the literature to describe different phenomena that need to be distinguished (Moore and Healy 2008): (1) people might be overconfident in their absolute performance and skills; this is called absolute overconfidence or overestimation; (2) people might be overconfident in their performance and skills relative to others; this is called relative overconfidence or overplacement; and (3) people might be overconfident in their forecasts and estimations about future events; this is called overprecision. This paper deals with the first two.

5.2.1 Absolute overconfidence

Studies on entrepreneurial overconfidence have often dealt with absolute overconfidence: Busenitz and Barney (1997) compared entrepreneurs and managers with respect to their susceptibility to overconfidence and to the representativeness heuristic. For measuring overconfidence, they asked participants to answer general knowledge questions and to state the probability with which they believe to have answered the respective questions correctly. Actual and estimated percentages were then compared. The more a person overestimated his or her performance, the higher the overconfidence of this person. This method replicates and goes back to Fischhoff et al. (1977) and Lichtenstein and Fischhoff (1977). Koellinger et al. (2007) report on the influence of subjective judgments about one’s own absolute skills on entry decisions. They based their analysis on data from 18 countries collected for the 2001 population survey of the Global Entrepreneurship Monitor (GEM). Investigating which variables are significantly associated with the decision to start a business they found that the strongest cross-national covariate is whether the respective person believed to have the sufficient skills, knowledge and ability to start a business. Furthermore, they found a negative correlation between this entrepreneurial confidence and survival chances of nascent entrepreneurs across countries. They argued that some countries exhibit relatively high rates of business start-ups because their inhabitants are more (over-)

confident than in other countries. Koellinger et al. (2007) showed that absolute overconfidence and subjective assessments of own absolute skills play an important role for business entry decisions. Forbes (2005) compares the degree of overconfidence of different types of entrepreneurs and finds that age, firm decision comprehensiveness and external equity funding affect the degree of overconfidence in entrepreneurs. In addition, founder-managers were found to be more overconfident than new-venture managers who did not found their firms. Forbes (2005) concludes that entrepreneurs' overconfidence is determined by both individual and contextual factors.

5.2.2 Relative overconfidence

In a competitive environment, success and failure are not only determined by absolute skills. They are much more driven by being better than one's competitors, i.e., by relative skills. Assessing their relative skills, people's beliefs about their own absolute skills are important but there is also another important component: their beliefs about the dispersion of abilities among their competitors. As people might fail to accurately assess their own abilities, they might also fail to accurately assess the ability level among their competitors. The role of underestimating the skills of competitors for market entry decision has been investigated by Camerer and Lovallo (1999). They coined the term reference group neglect for this phenomenon. In their influential study, Camerer and Lovallo (1999) combined the experimental paradigm of the classic market entry game (Selten and Güth 1982, Kahneman 1988, Rapoport 1995, Sundali et al. 1995, Rapoport et al. 1998) with skill-based payoffs that are typical for tournaments. They tested the hypothesis that overconfidence in own relative skills causes business entry mistakes and market overentry, a hypothesis that was previously stated by March and Shapira (1987) and Roll (1986). They find that over-entry is connected to overconfidence in one's relative skills and to neglecting whom one is competing against[15]. In their experiment, participants had to decide simultaneously about entering or not entering an experimental market where payoffs from entering depended on the participant's 'rank'. The *c* best ranked entrants made a profit from entering. All other entrants made a loss. Thus, only participants who believed to be among the *c* best

[15] For discussions of alternative explanation to the findings of Camerer and Lovallo (1999) see Hogarth and Karelaia (2009).

ranked entrants should enter. Thereby, ranks depended on either a chance device (random condition) or on the participants' relative skill compared to the other players in a logic puzzle, trivia quiz, or sports questions (skill condition). Importantly, these ranks were determined after entry decisions were made. Hence, when making their entry decisions, participants did not know their actual rank, but had to base their decision on their belief about their relative performance. Camerer and Lovallo (1999) compared entry rates in rounds with random ranks with the entry rates in rounds with skill ranks. They show that entry rates were significantly higher in rounds where payoffs were based on relative skill (skill condition) than in rounds with random ranks (random condition), leading to over-entry and negative industry profits in most rounds with skill-based payoffs. Furthermore, they compared entry rates of participants that were recruited via standard recruiting instructions with participants that were recruited using a 'self-selection' instruction. In the self-selection condition, students were asked to participate in an experiment in which performance on sports or current event trivia would determine their payoff. By this comparison they tested whether the entry differential between rounds with skill ranks and rounds with random ranks is larger for groups that self-selected into the task because they considered themselves as especially skilled in this domain. Indeed, they found that the gap between entry rates in both conditions is three times larger in the self-selection group. Their results support the hypothesis that overconfidence in own relative skill and reference group neglect lead to excess market entry and that the later is especially pronounced in domains where people believe to be competent.

Elston et al. (2006) conducted a series of experiments at two large start-up conventions, including a market entry experiment based on the experimental paradigm of Camerer and Lovallo (1999). Comparing entrepreneurs and a test-group that they classified as non-entrepreneurs, they did not find significant differences between entrepreneurs and the test group with respect to relative overconfidence. A result that can only be reconciled with the findings of Busenitz and Barney (1997) assuming either that entrepreneurs are *less* prone to underestimate their competitors than non-entrepreneurs – an assumption that is rather unintuitive – , or by assuming that the managers in Busenitz and Barney (1997) were less affected by absolute overconfidence than the non-entrepreneurs in Elston et al. (2006). This leaves room for further investigating potential differences between entrepreneurs and non-entrepreneurs.

5.2.3 Overconfidence and demand uncertainty

The role of overconfidence in business entry decisions was also investigated by Wu and Knott (2006). They modeled and tested market entry decisions by simultaneously considering ability uncertainty and demand uncertainty. Reconciling the risk-bearing characterization of entrepreneurs with the empirical result that entrepreneurs exhibit conventional risk aversion profiles, they argued that entrepreneurs are risk-averse with respect to demand uncertainty but overconfident or 'apparent risk-seeking' with respect to ability uncertainty. Entrepreneurs' overconfidence would outweigh risk aversion with respect to demand uncertainty when the degree of ability uncertainty is comparable to the degree of demand uncertainty. Testing their model on the aggregated market level with data from the banking industry, Wu and Knott (2006) find that entrepreneurs in aggregate behave as their model predicts. The present study considers demand uncertainty to account for these findings and to ascertain data that allows a comparison with Busenitz and Barney (1997), Wu and Knott (2006) and Elston et al. (2006).

5.3 Experiment

5.3.1 Experimental approach

Differences in relative overconfidence between entrepreneurs' and non-entrepreneurs' were tested in an economic experiment. The experiment was based on a simultaneous market entry scenario with tournament payoffs introduced by Camerer and Lovallo (1999). Demand uncertainty as considered by Wu and Knott (2006) was included by ambiguous information about the market capacity.

The experimental method allows specifying entry relevant skills in a way that enables to objectively measure these skills and to compare entrepreneurs and non-entrepreneurs. In accordance to Busenitz and Barney (1997), Camerer and Lovallo (1999), and Elston et al. (2006) skill was instrumentalized measuring performance in a general knowledge questionnaire. Individual performance in the general knowledge quiz was set in relation to the performance of the other players, determining the ‘rank’ of each player. The players’ ranks determined their payoffs from entering the experimental market. The better a player performed relative to the other players, the better his rank and the higher the probability that he would make a profit by entering.

5.3.2 Experimental design, samples and procedure

The experiment was conducted with 84 participants, 28 entrepreneurs and 56 non-entrepreneurs. Six sessions were run with 14 participants each. Entrepreneurs and non-entrepreneurs participated in separate sessions. All sessions were run at the experimental laboratory of a German university.

The entrepreneurs were recruited via online announcements. All of them were founders and managers of companies. Industries ranged from services, retailing, technology, and manufacturing. The average age of the entrepreneurs was 42 years (SD = 12.62). 53.6 percent of them were male and 46.4 percent were female. All entrepreneurs had been running their business for more than three years at the time they participated in the experiment. The non-entrepreneurs were students from different fields like in Camerer and Lovallo (1999) and Moore et al. (2007). Their average age was 26 years (SD = 0.64). They were recruited via class announcements and email invitations. The non-entrepreneurs sample consisted of 33.9 percent male and 66.1 percent female students. In order to account for differences in opportunity costs and wealth the show-up fee and the payoffs in the experiment were scaled up by a factor of three for the entrepreneurs.

Upon arrival participants were paid a show-up fee of 12 Euro (36 Euro for the entrepreneurs) and told to pocket it. Participants were then seated at separated computer desks. Communication between the participants was not allowed and participants did not know with whom they were playing. Instructions were displayed on the computer monitors and guided participants through the experiment. Additional hard copies of the instructions were distributed. Comprehension questions at the beginning assured that participants fully understood the instructions. The experiment consisted of three parts: In part one, all participants completed a general knowledge quiz with 14 binary choice questions knowing that their payoffs from the subsequent task would depend on how well they performed in this quiz. The questions were pre-tested to avoid performance differences between men and women and to adjust difficulty. Having completed the quiz, participants did not receive feedback about their performance. Instead, they continued with part two without knowing how many questions they actually answered correctly[16]. For part two, they were matched in groups of seven playing the following market entry game: participants were asked to decide simultaneously whether or not to enter an experimental market with a limited capacity *c* (representing the market demand). In this market, success depended on the participant's performance in the quiz as compared to the other six people in her group. Only the *c* best ranked entrants could make a profit. All further entrants would make a loss. The rank of a participant was determined by the number of correct answers in the quiz as compared to the other people in her group. The entrant with the highest number of correct answers had rank 1, the entrant with the second highest number of correct answers had rank 2. Ranks were unknown to the participants. Feedback about the ranks was only given at the very end of the experiment. All participants decided simultaneously and without being able to observe the others entering or not entering the market. The capacity (demand) of the market *c* was uncertain: it could vary between 1 and 5, whereby the distribution of *c* was not given to the participants in order to account for exogenous demand uncertainty as considered by Wu and Knott (2006). If a participant decided to enter and he was among the *c* best ranked entrants, he made a monetary profit of *K*. If he decided to enter but he was not among the *c* best ranked entrants, he made a monetary loss of *L*. The possible profit *K* was 22.50 Euro for the entrepreneurs and 7.50 Euro for the non-entrepreneurs. The possible loss *L* was 30 Euro for the entrepreneurs and 10 Euro for the non-entrepreneurs. The respective payoffs are displayed in Table 20.

[16] In Camerer and Lovallo (1999) the trivia questions were presented only after the market entry experiment. However, previous research has shown, that people prefer to bet on things that are yet not realized (e.g., Rothbart and Snyder 1970).This is explained by peoples' illusion of control. In order to eliminate potential effects of illusion of control, in the present study participants were confronted with the trivia task before the market entry game – still without giving them any information about the number of questions they answered correctly.

TABLE 20. PAYOFFS AS A FUNCTION OF ENTRANT RANK AND MARKET CAPACITY C

	ENTRANT RANK						
C	1	2	3	4	5	6	7
1	22.5€ [7.5€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]
2	22.5€ [7.5€]	22.5€ [7.5€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]
3	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]
4	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	- 30€ [-10€]	- 30€ [-10€]	- 30€ [-10€]
5	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	22.5€ [7.5€]	- 30€ [-10€]	- 30€ [-10€]

Participants played five rounds of this simultaneous market entry game. After they completed this, they played another five rounds in which they received information on the ability level of their competitors. In each round, participants were randomly re-matched so that they played against a different group of six opponents in each round. Between the rounds, participants did not receive any feedback about the outcome of a round. Instead, the outcomes of all rounds were presented in a table at the very end of the experiment. After all rounds were completed, participants were asked to state the number of players they expected to enter in the previous market entry game (a) in the first five rounds, and (b) in the second five rounds when they received information about the skill level of their competitors. For each correct estimate they received a small additional payoff to assure it was in their own interest to truthfully report on their expectations. Afterwards, participants risk attitude was measured using the Holt and Laury (2002) measure followed by a questionnaire including basic statistical data like age and gender. After all participants completed the questionnaire, one of the ten rounds was randomly selected as basis for the final payoff. Participants received a report about their performance in the quiz, about the results of all rounds, their decisions, and a list of their payoffs from the different parts of the experiment. Finally, participants were privately paid. The experiment was programmed and conducted using the software z-Tree (Fischbacher 2007).

5.3.3 Nash equilibria

If players knew their rank and the size of the market capacity, the best c players in a group should enter. All others should stay out because they would make a loss by entering. As in this experiment ranks – representing relative skills – and the market capacity – representing demand – were unknown, entry decisions mirrored the participants' beliefs about their true ranks and their belief about the realized market capacity.

Assuming, however, in accordance to Camerer and Lovallo (1999), that participants are risk-neutral and have common ignorant priors – i.e., assuming they believe to have equal chances to be among the c best-ranked players and assign equal probabilities to all possible realizations of *c*, the following payoff function can be derived:

Let $s_i = 0$ be the strategy of player *i* not to enter and let $s_i = 1$ denote the strategy of player *i* to enter the market. The payoff function of the average player is then given by:

$$\pi_i(s_i, m) = \begin{cases} 0 & \text{if } s_i = 0 \\ K & \text{if } s_i = 1 \text{ and } m \le c \\ \dfrac{Kc - L[m-c]}{m} & \text{if } s_i = 1 \text{ and } m > c \end{cases} \tag{10}$$

where π_i denotes the payoff for player *i* given his strategy choice s_i and total number of entrants *m* (including player *i*). The market capacity is denoted by c. If the total number of entrants does not exceed the market capacity, the average entrant's profit is $K > 0$ (K = 22.50 Euro for the entrepreneurs and 7.50 Euro for the non-entrepreneurs). If the total number of entrants exceeds the market capacity, the payoff of the average entrant equals the industry profit divided by the number of entrants. The industry profit is the accumulated payoff (gains and losses) of all entrants, whereby *c* entrants make a profit of *K* and *(m-c)* entrants make a loss of *L* (L = 30 Euro for the entrepreneurs and 10 Euro for the non-entrepreneurs), with $K = 0.75\ L$.

In equilibrium, players must be indifferent about entering or staying out of the market. If $m \le c$, entering is a dominant strategy as $K > 0$. If $m > c$, the average player should be indifferent between entering and staying out when $(Kc - L[m-c]/m) = 0$. This happens when $m = Kc/L + c$; i.e., when $m = 1.75\ c$. Consequently, in pure strategy equilibria the number of entrants is m = 1.75 c; i.e., the highest integer of entrants below 1.75 c.

To derive the mixed strategy equilibrium, let $p(s_1)$ be the probability with which each player selects to enter and let $p(s_0) = 1 - p(s_1)$ be the probability with which each player selects to stay out of the market. Then the probability that m players enter and N-m players stay out is

$$(11) \qquad p(m) = p(s_1)^m \cdot (1 - p(s_1))^{N-m} \cdot \binom{N}{m}$$

In the mixed strategy equilibrium, players enter with probability p^* solving:

$$(12) \qquad p^*(s_1) \cdot K + (1 - p^*(s_1)) \cdot \sum_{m>1.75c}^{N} [\frac{Kc - L[m-c]}{m}] \cdot p^*(s_1)^m \cdot (1 - p^*(s_1))^{N-m} \cdot \binom{N}{m} = 0$$

Table 21 shows the total number entrants for which the players are indifferent between entering and staying out for different values of c, the number of entrants in pure strategy equilibria and the corresponding mixed strategy equilibrium.

TABLE 21. OVERVIEW EQUILIBRIA

C	m = 1.75 c	enter if	# ENTRANTS IN PURE EQUILIBRIA	MIXED STRATEGY EQUILIBRIA p^*
1	1.75	$m - 1 \leq 1.75$	1	0.14
2	3.50	$m - 1 \leq 3.50$	3	0.43
3	5.25	$m - 1 \leq 5.25$	5	0.71
4	7	*enter always*	6 or 7	-
5	8.75	*enter always*	7	-

Assuming that people assign equal probabilities to all possible realizations of c = [1; 5] they would expect a market capacity of 3 to be realized. In this case the mixed strategy equilibrium predicts a mean entry rate of 0.71.

5.4 Results

5.4.1 Analysis

Random-effects logit regressions of entry have been estimated to test the following hypothesis:

HYPOTHESIS 1: Entrepreneurs enter more frequently than non-entrepreneurs.

HYPOTHESIS 2: Entrepreneurs are less affected by reference group neglect than non-entrepreneurs; i.e., they react less to information about the ability dispersion in their reference group (interaction between *group* and *reference group information*).

5.4.2 Entrepreneurs' and non-entrepreneurs' entry rates

When no information about the reference group was given, entrepreneurs' mean entry rate was 70 percent, non-entrepreneurs' mean entry was 60 percent. In the last five rounds, when participants received information about their reference group performance, entry rates decreased to 63 percent among entrepreneurs and to 55 percent among non-entrepreneurs. Table 22 gives an overview of the mean entry rates of entrepreneurs and non-entrepreneurs in rounds without and with reference group information (RG information).

TABLE 22. MEAN ENTRY RATES

GROUP	GENDER	RG INFORMATION	MEAN ENTRY RATE	SD	SE
Entrepreneurs	total (N=28)	without	0.70	0.310	0.059
		with	0.63	0.356	0.067
	male	without	0.75	0.316	0.082
		with	0.67	0.335	0.087
	female	without	0.65	0.307	0.085
		with	0.59	0.387	0.107
Non-entrepreneurs	total (N=56)	without	0.60	0.318	0.043
		with	0.55	0.329	0.044
	male	without	0.78	0.282	0.065
		with	0.79	0.294	0.068
	female	without	0.50	0.297	0.049
		with	0.42	0.274	0.045

In the regression analysis (Table 25), a dummy variable accounts for the effect of *reference group information.* Entry rate differentials between rounds without and with reference group information have been calculated for each individual, yielding the size of individual reference group neglect. The effect of size of reference group neglect was considered in a separate logit model that has been estimated for the first five rounds (see Table 26 in the appendix).

5.4.3 Skills, beliefs, risk attitude

Table 23 contains mean values of the independent variables skill (and rank), risk aversion, and belief for entrepreneurs and non-entrepreneurs.

TABLE 23. MEAN VALUES OF THE INDEPENDENT VARIABLES

	ENTREPRENEURS			NON-ENTREPRENEURS		
MEANS	TOTAL	MALE	FEMALE	TOTAL	MALE	FEMALE
Skill	8.1	8.6	7.3	8.0	9.6	7.2
Rank	7.0	5.8	9.0	7.4	4.6	8.7
Risk aversion	6.3	6.3	6.3	6.0	4.4	6.8
Belief	4.4	4.5	4.2	4.2	4	4.3

Entrepreneurs on average answered 8.1 out of 14 questions correctly, non-entrepreneurs 8.0 questions. The belief about the total number of entrants was on average 4.4 out of a maximum possible of 7 within the group of entrepreneurs and 4.2 within the group of non-entrepreneurs. Mean risk aversion was 6.3 among the entrepreneurs and 6.0 among non-entrepreneurs whereby a higher score represents a higher degree of risk aversion. Mean values show that some of these variables are differently distributed across gender. A significant correlation between *gender* and *risk aversion* was found; women being more risk-averse than man. This result is consistent with the literature on gender differences in risk attitudes (Eckel and Grossman 2002). There is also a highly significant correlation between *gender* and *skill* (and consequently with *rank*[17]) men answering more questions correctly than women. On average male respondents answered about 2 (out of 14) more questions correctly than female respondents. This result is surprising as the quiz questions were pre-tested and had been chosen to generate a medium difficulty and to avoid gender differences in performance. The result that there is still a gender difference in performance is thus likely to be a caused by the tournament character of the experiment that was absent in the pre-test of

[17] Rank and skill are correlated by definition. The fact that the correlation between rank and skill does not equal 1 goes back to the ranking rule. If two players had the same number of correct answers the ranking among them was based on the time they needed to complete the questionnaire. This ranking rule was also applied in Camerer and Lovallo (1999).

the questions. In the experiment, participants knew that their payoffs from the subsequent interactive task would depend on the number of questions they answer correctly and on the time they needed to answer these questions. This might have created a tournament atmosphere which is known to cause gender gaps in performance, particularly in mixed-sex sessions (Niederle and Vesterlund 2007). For *belief* no significant correlations were found. Table 24 presents the correlations among the independent variables.

TABLE 24. CORRELATIONS BETWEEN INDEPENDENT VARIABLES

	1	2	3	4	5
1. Group					
2. Gender	0.189				
3. Skill	-0.034	0.450***			
4. Rank	0.017	0.445***	-0.904***		
5. Belief	0.030	0.029	-0.089	0.075	
6. Risk aversion	0.076	-0.353**	-0.145	0.179	-0.207

*** Significant at the 1 percent level; ** Significant at the 5 percent level; * Significant at the 10 percent level.

5.4.4 Regressions

Several random-effects logit regressions of entry have been estimated to test hypothesis 1 and 2[18]. The dependent variable *entry* is coded with '1' when a participant decided to enter and '0' when a participant decided not to enter. *Gender* is coded '1' for male participants and '0' for female participants. *Group* is coded '1' for entrepreneurs and '0' for non-entrepreneurs. The variable *reference group information* is coded with '1' for rounds in which the participants received information about the performance of their competitors (round 6-10) and '0' for rounds where they did not receive this information (round 1-5). Model 1 considers *group*, *gender*, *reference group information*, the *skill* level of the respective participant, their level of *risk aversion* and their *belief* about the number of entrants in round 1-5. Model 2 also accounts for the interaction effect of *group* and *gender*. Model 3 considers the interaction between *reference group information* and *skill,* while model 4 further considers interactions of *reference group information* and *group* and *reference group information* and *gender*.

[18] All estimations were run in STATA.

TABLE 25. RANDOM-EFFECTS LOGIT MODELS

MODEL	(1)	(2)	(3)	(4)
Group (0/1)	0.303 (0.477)	0.848 (0.645)	0.305 (0 .477)	0.810 (0.686)
Gender (0/1)	1.263*(0.517)	1.813**(0.684)	1.261*(0.517)	1.819*(0.725)
Reference group information (0/1)	-0.402*(0.192)	-0.402*(0.192)	-0.802 (0.715)	-0.422 (0.248)
Skill	0.028 (0.103)	0.011 (0.103)	0.001 (0.113)	0.011 (0.103)
Risk aversion	-0.472***(0.131)	-0.415**(0.136)	-0.472***(0.132)	-0.415**(0.136)
Belief	0.327*(0.154)	0.364*(0.156)	0.327*(0.154)	0.364 (0.156)
*Group*gender*		-1.238 (0.992)		-1.241 (0.992)
*Reference group information*skill*			0.051(0.088)	
*Reference group information*group*				0.075 (0.456)
*Reference group information*gender*				-0.009 (0.448)
Constant	1.567 (1.479)	1.038 (1.521)	1.772 (1.521)	1.046 (1.521)
σ_u	1.463 (0.202)	1.442 (0.200)	1.462 (0.202)	1.442 (0.200)
χ^2	39.16	40.67	39.54	40.69
Number of observations	740	740	740	740
Number of participants	74	74	74	74

Dependent variable = entry (0/1)

Random-effects specification = subject id

$^{***}p<0.001$; $^{**}p<0.01$; $^{*}p<0.05$

Group does not have a significant main effect on entry. Also the interaction effect of *group* and *reference group information* was not significant. Instead behavior was largely driven by *gender* – men enter more than women – and *risk aversion*. Furthermore, when reference group information was given, participants entered significantly less than without this information. The absolute skill level of the participants did not have an influence on their entry behavior. Entry beliefs had a positive influence on entry. Interactions between *reference group information* and *skill* and *reference information* and *gender* were not significant.

Considering entry behavior in the first five rounds separately, the effect of the size of reference group neglect was considered (Table 26 in the appendix contains the results). The size of the reference group neglect did not have a significant effect on entry. Also, possible interactions between the size of the reference group neglect and group and between the size of the reference group neglect and gender did not have an effect on entry. The direction of the other effects remains.

5.5 Discussion

The main result presented here indicates that entrepreneurs are not more susceptible to relative overconfidence and not more willing to enter skill-based competition than non-entrepreneurs. Being confronted with the same situation, participants in both groups exhibit similar entry decisions – even in the presence of ambiguous market information. This implies that it is not their 'ego' that distinguishes entrepreneurs from non-entrepreneurs. This result is in line with the findings by Elston et al. (2006) and consistent with other recent studies that used incentivized experiments and do not find significant differences in the decision making of entrepreneurs and non-entrepreneurs where one would expect differences (Sandri et al. 2010, Holm et al. 2010, Schade and Boewe 2011).

Given the small sample size in the present study, small differences between entrepreneurs and non-entrepreneurs might not have been detected just because they were too small. However, the fact that the gender gap in entry remains within the group of entrepreneurs, supports the reported findings: If overconfidence was a trait necessary to overcome the risk associated with founding a business the difference between male and female entrepreneurs should be smaller than between female entrepreneurs and other women. Results show, however, that the gender effect outweighs being an entrepreneur.

Entrepreneurs were also not less (or more) effected by the reference group neglect than non-entrepreneurs. This result raises questions about the compatibility of the findings of Busenitz and Barney (1997) and Elston et al. (2006). Among the many possible explanations for the incompatibility of Busenitz and Barney (1997) and Elston et al. (2006) but also the incompatibility with the present results, the following two seem most plausible: (1) Busenitz and Barney (1997) compared managers of large companies with entrepreneurs while Elston et al. (2006) considered salaried employees as a test group. This study tested differences between entrepreneurs and students which are used as subjects in most studies on overconfidence (e.g., Camerer and Lovallo 1999, Moore et al. 2007). These sample differences might have lead to the incompatibility of results. However, the results of Elston et al. (2006) and the present study are consistent. (2) The study by Busenitz and Barney (1997) was based on a questionnaire while Elston et al. (2006) and this study used monetary incentives to assure that people behave in accordance to their true preferences. This also might have affected results.

Comparing entry rates with the mixed strategy equilibrium, no overentry could be observed under demand uncertainty. Hence, in the present study the level of overconfidence was not high enough to outweigh participants risk aversion with regards to uncertainty about the market size. This result differs from Wu and Knott (2006). They suggest that overconfidence should outweigh aversion towards demand uncertainty when ability uncertainty is comparable to or higher than demand uncertainty. This was the case in the present study: ability uncertainty had a variance of 2.3 while demand uncertainty had a variance of 2. However, Camerer and Lovallo (1999) have shown that relative overconfidence increases and is up to three times larger when people self-select into to task which was the case in the study by Wu and Knott (2006). Hence, assuming that the effect would have been three times larger when people would have self-selected into the task would have lead to a distinct overentry and makes the results reconcilable. For the present study self-selection was not possible as this would not have allowed comparing entrepreneurs and non-entrepreneurs and in particular to compare the results to previous findings by Busenitz and Barney (1997) and Elston et al. (2006).

5.6 Conclusion

This study investigated whether entrepreneurs are more overconfident in their relative skills than non-entrepreneurs and more willing to enter skill-based competition under demand uncertainty. Results show no significant differences in relative overconfidence between entrepreneurs and others. Hence, it is not their level of relative overconfidence that distinguishes entrepreneurs from non-entrepreneurs. Also entrepreneurs did not differ from non-entrepreneurs in their susceptibility to reference group neglect. Instead, behavior was largely driven by gender differences, a result that is in line with findings on overconfidence in non-entrepreneurs. The fact that these differences remain in the group of entrepreneurs underlines that entrepreneurs do not necessarily need a high degree of overconfidence to overcome the risk associated with starting a business.

References

Baron, R.A., 1998. "Cognitive mechanisms in entrepreneurship: Why and when entrepreneurs think differently than other people". *Journal of Business Venturing,* 13, 275-294.

Bernardo, A.E., and Welch, I., 2001. "On the evolution of overconfidence and entrepreneurs". *Journal of Economics and Management Strategy,* 10, 301-330.

Brockhaus, R.H., 1980. "Risk Taking Propensity of Entrepreneurs". *Academy of Management Journal,* 23, 509-520.

Busenitz, L.W., and Barney, J.B.,1997. "Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making". *Journal of Business Venturing,* 12, 9-30.

Camerer, C. and Lovallo, D., 1999. "Overconfidence and excess entry: an experimental approach". *American Economic Review,* 89, 306-318.

Cooper, A.C., Woo, C.Y., and Dunkelberg, W.C., 1988. "Entrepreneurs' perceived chances for success". *Journal of Business Venturing,* 3, 97-108.

Cramer, J.S., Hartog, J., Jonker, N., and Van Praag, C.M., 2002. "Low risk aversion encourages the choice for entrepreneurship: an empirical test of a truism". *Journal of Economic Behavior & Organization*, 48, 29-36.

Eckel, C.C., and Grossman, P.J., 2002. "Sex differences and statistical stereotyping in attitudes toward financial risk". *Evolution and Human Behavior, 23*, 281-295.

Elston, J.A., Harrison, G., and Rutström, E.E, 2006. "Experimental Economics, Entrepreneurs and the Entry Decision". UCF Working paper.

Fischbacher, U., 2007. "Z-Tree: Zurich Toolbox for Ready-made Economic Experiments". *Experimental Economics,* 10, 171-178.

Fischhoff, B., Slovic, P., and Lichtenstein, S., 1977. "Knowing with certainty: The appropriateness of extreme confidence". *Journal of Experimental Psychology: Human Perception and Performance,* 3, 552-564.

Forbes, D.P., 2005. "Are some entrepreneurs more overconfident than others?". *Journal of Business Venturing,* 20, 623-640.

Hayward, M.L.A., Shepherd, D.A, and Griffin, D., 2006. "A hubris theory of entrepreneurship". *Management Science*, 52, 160-172.

Hogarth, R.M., and Karelaia, N., 2009. "Entrepreneurial success and failure: Confidence and fallible judgment". UPF and INSEAD working paper.

Holm, H., Nee, V., and Opper, S., 2010. "Entrepreneurs Under Uncertainty: An Economic Field Experiment". CSES Working paper 60.

Holt, C.A., and Laury, S.K., 2002. "Risk Aversion and Incentive Effects". *American Economic Review,* 92, 1644-1655.

Kahneman, D., 1988. "Experimental economics: A psychological perspective". In R. Tietz, W. Albers & R. Selten (Eds.), *Bounded Rational Behavior in Experimental Games and Markets*, 11-18. Berlin: Springer-Verlag.

Kahneman, D., and Lovallo, D., 1993. "Timid choices and bold forecasts: A cognitive perspective on risk taking". *Management Science, 39,* 17-31.

Kihlstrom, R., and Laffont, J.J., 1979. "A general equilibrium entrepreneurship theory of the firm based on risk aversion". *Journal of Political Economy,* 87, 719-48.

Knight, F.H., 1921. *Risk, Uncertainty, and Profit.* Boston and New York: Houghton Mifflin.

Koellinger, P., Minniti, M., and Schade, C., 2007. "I think I can, I think I can: Overconfidence and entrepreneurial behavior". *Journal of Economic Psychology,* 28, 502-527.

Kramer, R., Newton, P., and Pommerenke, P.L., 1993. "Self-enhancement biases and negotiator judgement: Effects of self-esteem and mood". *Organizational Behavior and Human Decision Processes*, 56, 110-133.

Lichtenstein, S., and Fischhoff, B., 1977. "Do those who know more also know more about how much they know?". *Organizational Behavior and Human Performance*, 20, 159-183.

MacCrimmon, K.R., and Wehrung, D.A., 1990. "Characteristics of Risk Taking Executives". *Management Science*, 36, 422-435.

March, J.G., and Shapira, Z., 1987. "Managerial Perspectives on Risk and Risk Taking". *Management Science*, 33, 1404-1418.

Masters, R., and Meier, R., 1988. "Sex differences and risk taking propensity of entrepreneurs". *Journal of Small Business Management*, 26, 31-35.

Miner, J.B., and Raju, N.S., 2004. "Risk propensity differences between managers and entrepreneurs and between low- and high-growth entrepreneurs: A reply in a more conservative vein". *Journal of Applied Psychology*, 89, 3-13.

Moore, D.A., and Healy, P.J., 2008. "The Trouble with Overconfidence". *Psychological Review,* 115, 502-517.

Moore, D.A., Oesch, J.M., and Zietsma, C., 2007. "What competition? Myopic self-focus in market entry decisions". *Organization Science*, 18, 440-454.

Niederle, M., and Vesterlund, L., 2007. "Do Women Shy away from Competition? Do Men Compete too Much?". *Quarterly Journal of Economics,* 122, 1067-1101.

Odean, T., 1998. "Volume, volatility, price, and profit when all traders are above average". *Journal of Finance*, 53, 1887-1934.

Perman, S., 2005. Interview with Brian Wu: "Ego makes Entrepreneurs?" *Bloomberg Businessweek.*http://www.businessweek.com/smallbiz/content/feb2005/sb2005021_6109_sb013.htm

Rapoport, A., 1995. "Individual strategies in a market entry game". *Group Decision and Negotiation,* 4, 117-133.

Rapoport, A., Seale, D.A., Erev, I. and Sundali, J.A.,1998. "Equilibrium play in large group market entry games". *Management Science,* 44, 119-141.

Roll, R., 1986. "The Hubris Hypothesis of Corporate Takeovers". *Journal of Business*, 59, 197-216.

Rothbart, M., and Snyder, M., 1970. "Confidence in the prediction and postdiction of an uncertain outcome". *Canadian Journal of Behavioral Science,* 2, 38-43.

Sandri, S., Schade, C., Mußhoff, O., and Odening, M., 2010. "Holding on for too long? An experimental study on inertia in entrepreneurs' and non-entrepreneurs' disinvestment choices." *Journal of Economic Behavior & Organization,* 76, 30-44.

Schade, C. and Boewe, S., 2011. "Market entry decisions after gains and losses: gender matters, being an entrepreneur does not". Unpublished manuscript.

Selten, R., and Güth, W., 1982. "Game Theoretical Analysis of Wage Bargaining in a Simple Business Cycle Model". Journal of Mathematical Economics, 10, 177-195.

Simon, M., Houghton, S.M., and Aquino, K., 2000. "Cognitive biases, risk perception, and venture formation: How individuals decide to start companies". *Journal of Business Venturing*, 15, 113-134.

Stewart, W.H., and Roth, P.L., 2001. "Risk propensity differences between entrepreneurs and managers: a meta-analytic review". *Journal of Applied Psychology,* 86,145-153.

Sundali, J., Rapoport, A, and Seale, D.A., 1995. "Coordination in Market Entry Games with Symmetric Players". *Organizational Behavior and Human Decision Processes,* 64, 203-218.

Svenson, O., 1981. "Are we less risky and more skillful than our fellow drivers?". *Acta Psychologica*, 47, 143-151.

Wu, B., and Knott, A.M., 2006. “Entrepreneurial Risk and Market Entry”. *Management Science,* 52, 1315-1330.

Appendices

Appendix I: Tables

TABLE 26. RANDOM-EFFECTS LOGIT MODEL FOR ROUND 1-5

MODEL	(1)	(2)	(3)
Group (0/1)	0.127 (0.489)	0.178 (0.472)	0.195 (0.462)
(Gender (0/1)	1.118*(0.535)	1.097*(0.517)	1.128*(0.505)
Skill	0.031 (0.107)	0.030 (0.103)	0.035 (0.101)
Risk aversion	-0.318*(0.136)	-0.323*(0.132)	-0.321*(0.128)
Belief	0.358*(0.159)	0.327*(0.154)	0.315*(0.153)
Reference group neglect		-1.149 (0.900)	
Group reference group neglect*			1.906 (1.830)
Belief reference group neglect*			-0.3741 (0.265)
Constant	0.513 (1.515)	0.649 (1.464)	0.571 (1.434)
σ_u	1.218 (0.279)	1.139 (0.280)	1.091 (0.282)
χ^2	20.94	23.43	24.47
Number of observations	296	296	296
Number of participants	74	74	74

Dependent variable = entry (0/1)

Random-effects specification = subject id

$^{***}p<0.001$; $^{**}p<0.01$; $^{*}p<0.05$

Appendix II: Instructions - selected parts

Explanations of experimental procedures are added in *italic*. All payoffs were scaled up down by factor 3 for the non-entrepreneurs.

At arrival in the experimental laboratory participants were paid a participation fee in cash. After being seated at their computer desks, and before beginning with the actual experiment, they received following information:

> Welcome!
>
> In this experiment, you will be asked to take various decisions. At the end of the experiment you will be paid for your participation. The amount you will receive depends on the decision you have made and on the decisions other participants have made.
>
> The experiment consists of three parts. In the first part, you will take a knowledge quiz. In the second part, you will play a game with six other players. In the third part, you will be asked to compare different lotteries. In the end we will ask you a few further questions. The entire experiment will take about 60-90 minutes.
>
> After you have concluded all parts of the experiment we will clear the payoffs from each part of the experiment and pay out the final amount to you in cash.
>
> All information will be treated as strictly confidential. Your anonymity is being ensured at any time.
>
> Next

Participants then answered 14 binary choice quiz questions. They did not receive information about their results.

> Part 2: The Game
>
> In the second part of the experiment you will play 10 rounds of a 7-player game. In each round you will play against another randomly chosen group of 6 anonymous counterparts.
>
> Next

Part 2: The Game

Rules of the game:

In this game, 7 players will decide simultaneously to enter a market or not. The market has a limited size, i.e., only a certain number of players can enter with profits. The rest who enters will suffer a loss. Whether you gain a profit or make a loss when you enter depends on the number of correct answers given in the quiz in part 1.

From all entrants only the ones who performed best in the quiz will make profits. The ones who enter the market and did worse in the quiz will suffer a loss. The number of players that can possibly make a profit (the so called market capacity c) might vary from round to round.

Example: If the market capacity is c=3 the three best ranked players who enter the market will make profits and all the other players who enter will make a loss. If we have a market capacity of c=4, the four best ranked players will make profits while the rest who enters makes losses, and so on.

If a player decides not to enter he will make neither profits nor losses in this particular round.

None of the players knows their own number of correct answers from the quiz or the number of correct answers of their counter players.

Next

Part 2: The Game

During the experiment you will not receive feedback about the results of previous rounds. Instead the results of all rounds will be summarized in an overview at the end of the experiment. One of the rounds will be randomly chosen. The profit/ loss that you achieved in this round will then be added or deducted from your payoff from the experiment. The other rounds will not be paid out.

Since every round could be chosen, please consider all decisions with equal attentiveness.

Next

Participants played 5 rounds with the following instructions:

Round 1

You and six other players will decide simultaneously to enter a market or not.

The market has a limited size so that only a certain number of players can enter with profits.

The payoffs for those who enter the market are determined in the following way:

According to the number of right answers in the quiz, a rank is assigned to each entering player. The player with the highest number of correct answers is ranked number 1, the player with second highest number of correct answers is ranked number 2 and so on. In case several players have the same number of correct answers they will additionally be ranked by their speed answering the quiz. Thereby the fastest player gets the best and the second fastest player the second best rank and so on.

Depending on the market capacity c the best ranked players receives a payoff of 22.50 €. The others who chose to enter the market loose each 30 €. The market seize is unknown to every player when taking the decisions. Once each player has taken her decision, the size of the market will be determined via a random mechanism.

The players merely know that the following market sizes are possible: 1, 2, 3, 4, 5.

The possible payoffs are presented below.

In case of market entry:

	Rank of the player in the quiz						
c	1	2	3	4	5	6	7
1	22.50 €	- 30 €	- 30 €	- 30 €	- 30 €	- 30 €	- 30 €
2	22.50 €	22.50 €	- 30 €	- 30 €	- 30 €	- 30 €	- 30 €
3	22.50 €	22.50 €	22.50 €	- 30 €	- 30 €	- 30 €	- 30 €
4	22.50 €	22.50 €	22.50 €	22.50 €	- 30 €	- 30 €	- 30 €
5	22.50 €	22.50 €	22.50 €	22.50 €	22.50 €	- 30 €	- 30 €

In case of not-entering: If a player chooses not to enter he neither makes a profit nor a loss in this round.

Please decide now whether you want to enter the market or not:

Entry	No Entry

After five rounds, participants entered a second block of rounds in which they received additional information about the performance distribution in their reference group:

New Information

For each of the following rounds players will receive information on their counterparts' results from the knowledge quiz, i.e., the number of correct answers in the knowledge quiz.

Since you will be playing against different players in each round, you will receive information on your counterparts' results before each round.

Next

Further Rounds

In each of the following rounds players will be informed about their counterparts' number of correctly answered quiz questions (out of 14).

You will now continue playing the game for another five rounds. The same conditions apply as before:

In each round, players are randomly re-matched so that you play against another group of 6 players.

The results of each round will only be reported to you by the end of the experiment.

At the end of the experiment, the payoff relevant round will be determined via a random draw.

Next

Example screen for reference group information:

Round 6

The following table presents the quiz results of each of your counterparts in this round.

For instance, you see how many questions (out of 14) your counterparts answered correctly.

Counterpart	Number of Correct Answers

Participants played five further rounds (round 6-10) receiving reference group information in each round.

Eidestattliche Erklärung

Hiermit versichere ich, dass ich die vorliegende Arbeit ohne fremde Hilfe selbständig verfasst und nur die aufgeführten Quellen und Hilfsmittel benutzt habe. Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt.

Sabrina Böwe

Berlin, den 05. August 2011